AERONAUTICAL ENGINEERING REVIEW

JUNE 1950

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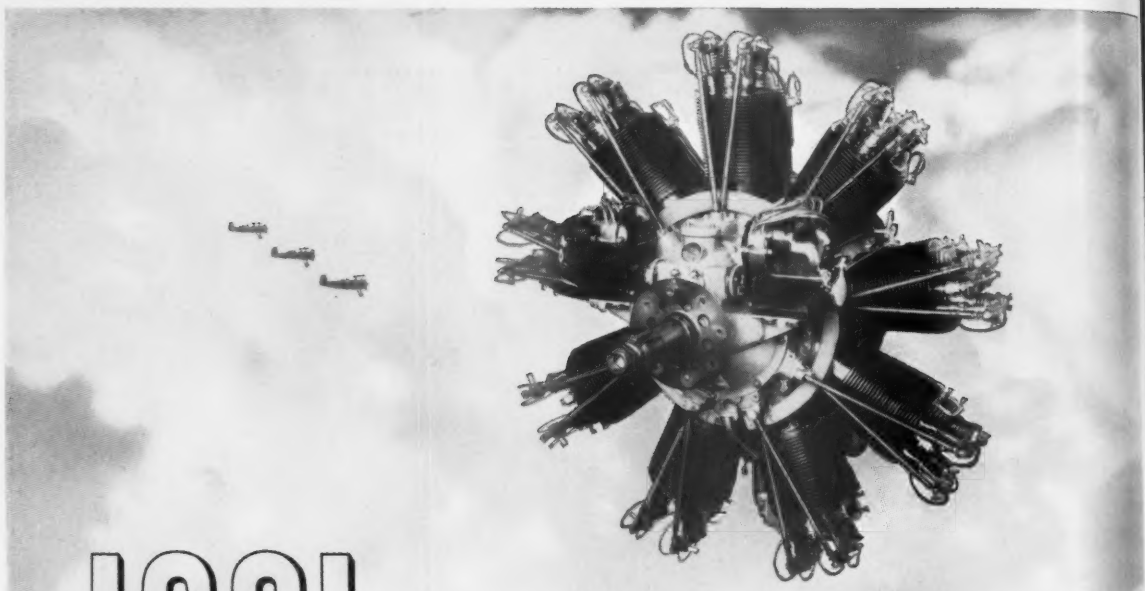
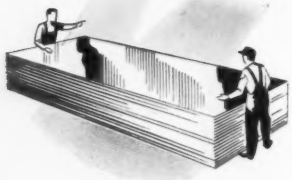


1921

Alcoa Aluminum was right for America's first radials

Aviation progress leaped ahead when the Lawrance 9-cylinder radial engine passed its Navy acceptance test early in 1921. For the first time, America had a fully successful, air-cooled engine of more than 100 hp. With few basic changes, the Lawrance engine was developed into the famous Wright "Whirlwind"—destined to power a long series of record-breaking flights. In all these first radials, Alcoa Aluminum's light weight and rapid heat conductivity made it the choice for cylinder heads, pistons and crankcases.

1950



Alcoa pioneers again with *larger* Aluminum Plate

Air frame fabrication has come a long way since aluminum became the leading flight material. New shop methods. New design tricks. New forms of aluminum, too. For instance, Alcoa recently made available aircraft plate in greater widths up to 120″, longer lengths up to 39′ and a weight per piece up to 4,000 pounds—opening the way to lower costs, higher performance.

Whatever your requirements, look to Alcoa as your "Flight-metal Headquarters". ALUMINUM COMPANY OF AMERICA, 1801F Gulf Building, Pittsburgh 19, Pennsylvania.

Send for your free copy of "How to Use High-strength Aluminum Alloy", a convenient engineering reference to guide your use of 75S.

ALCOA

ALCOA ALUMINUM MAGNESIUM

It's GOODYEAR Brakes and Wheels 100% on AA

GOODYEAR
AVIATION
PRODUCTS

WE think it is highly significant that American Airlines Inc., world's largest operator of passenger aircraft, has *every* ship in its Flagship Fleet equipped with world-famous Goodyear disc-type brakes and light-weight magnesium alloy wheels. Because these brakes have proved their superiority for stopping power, safety, dependability, *more modern commercial aircraft are equipped with Goodyear disc-type brakes than any other kind—and the number's increasing steadily!*

AIRCRAFT LANDING GEAR COMPONENT

An outstanding example of forging technique—the piercing operation in the case of this 276-lb. alloy steel forging results in a weight saving of approximately 30 per cent in addition to an improved metallurgical structure.

For the greatest combination of physical properties (tensile and compressive strength, ductility, impact and fatigue strength) with minimum weight and uniform quality no other method of forming metal compares with the forging process.

In large and medium-size forgings of steel and light alloy—there is no substitute for Wyman-Gordon experience.

Standard of the Industry for More Than Sixty Years

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Forgings of Aluminum, Magnesium, Steel

WORCESTER, MASSACHUSETTS, U. S. A.

HARVEY, ILLINOIS - - - DETROIT, MICHIGAN

Official Navy Photo

Cover—Navy Convair XP5Y-1 turboprop flying boat shown on its maiden flight.

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SUBSCRIPTION RATES

Aeronautical Engineering Review: United States and possessions, 1 year, $3.00; single copies, $0.50. Foreign countries including Canada (American Currency Rates), 1 year, $3.50; single copies, $0.50.

Entered as second-class matter at the Post Office, Easton, Pa., April 29, 1942. Acceptance for mailing at a Special Rate of Postage as provided for in the Act of August 24, 1912.

Publication Office: 20th & Northampton Streets, Easton, Pa.

Editorial Office: 2 East 64th Street, New York 21, N.Y.

Notices of change of address should be sent to the Institute at least 30 days prior to actual change of address.

Statements and opinions expressed in the *Aeronautical Engineering Review* are to be understood as individual expressions and not those of the Institute.

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AERONAUTICAL ENGINEERING REVIEW

Vol. 9 **JUNE, 1950** **No. 6**

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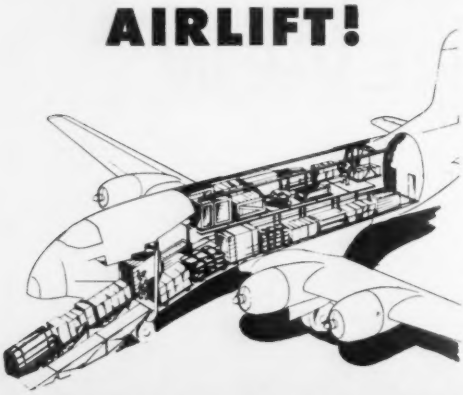
Published Monthly by the Institute of the Aeronautical Sciences, Inc.

GIANT ALL-PURPOSE AIRLIFT!



C-124—mammoth transport designed by Douglas—is the most versatile and flexible cargo and troop carrier in the air today.

Sixty-five of these sky giants are in production for the Air Force, with deliveries scheduled soon to Supply Squadrons of the Strategic Air Command.

Each plane is able to carry anything up to 50,000 pounds—diversified general cargo, 200 troops, or 94% of all military vehicles, *fully assembled.* This means that *only* a C-124 fleet can transport by air an entire standard infantry division, including all the millions of pounds of airlift required for its continued equipment and support. The C-124 is also self-sufficient for rapid loading and unloading.

Furthermore, propeller-turbine engines can be readily installed in the current C-124 design, making possible more payload, longer range and greater speed.

LONG BEACH PLANT OF DOUGLAS AIRCRAFT COMPANY, INC.

DEPEND ON DOUGLAS

30TH ANNIVERSARY YEAR

I.A.S. News

A Record of People and Events of Interest to Institute Members

Annual Summer Meeting Program Nears Completion

Experts to Gather in Los Angeles on July 12—14 to Discuss Varied Aspects of High-Speed Aircraft Development; Activities Include Dinner at Ambassador Hotel and Presentation of Chanute and Bane Awards.

THE 1950 ANNUAL SUMMER MEETING of the Institute of the Aeronautical Sciences will get under way in Los Angeles on Wednesday morning, July 12, with the first of five Technical Sessions. As in 1949, the sessions will be held in the I.A.S. Western Headquarters Building. Officers and members of the Los Angeles Section, under the Chairmanship of Philip A. Colman, A.F.I.A.S., Chief Aerodynamics Engineer, Lockheed Aircraft Corporation, will act as hosts. The three-day gathering, a highspot in the I.A.S. activity program, will feature the presentation of technical papers and open discussion of the complex problems confronting designers and users of today's high-performance aircraft and engines.

▸ **Technical Sessions**—Following registration at 8:30 a.m. Wednesday morning, the Technical Sessions will get under way promptly at 9:00 a.m. in the I.A.S. Building Auditorium. A brief résumé of the topics to be covered at the Sessions follows.

• **July 12, Aerodynamics, 9:00 a.m.**—Supersonic wing-body interference; experiments in transonic flow; minimum drag of thin airfoils in frictionless flow; and effect of boundary layer on supersonic diffuser design.

Stability, Control, and Guidance, 1:30 p.m.—Progress in stall research; drop model techniques for stability and control research; unconventional wind-tunnel testing techniques for the development of swept-wing aircraft; and fundamental limitations on automatic navigation.

Turbine-Powered Aircraft, 8:00 p.m.—Civil air regulations for turbine-powered aircraft, and operating problems of turbine-powered aircraft.

• **July 13, Aeroelasticity and Structures, 9:00 a.m.**—Aeroelastic problems in a high-speed bomber; dynamic analysis of aeroelastic aircraft by transfer function-Fourier methods; Project "Thunderstorm"; and a superposition method for calculating the aeroelastic behavior of swept wings.

Propulsive Systems, 1:30 p.m.—Future developments and prospects for propellers; current turboprop power-plant installations; flight pressure refueling; and performance of turbojet engines.

▸ **Dinner**—At 6:00 p.m. Thursday, July 13, a reception will be given in the Ambassador Hotel. Following this reception, the Dinner will begin promptly at 7:00 p.m. in the Embassy Room of the Ambassador. Presentation of The Octave Chanute Award (given "for a notable contribution made by a pilot to the Aeronautical Sciences") and The Thurman H. Bane Award (given "to an officer or civilian of the Air Materiel Command for an outstanding achievement in aeronautical development") will be made during the Dinner, and a prominent guest speaker will address I.A.S. members and their guests. J. H. Kindelberger, I.A.S. President and Chairman of the Board, North American Aviation, Inc., will act as Toastmaster at the Dinner.

Philip A. Colman, Chairman of the Los Angeles Section.

Copies of the final program of the 1950 Annual Summer Meeting will be mailed to all members later this month. This final program will contain a complete listing of all the papers to be presented at the Technical Sessions and full information on registration and Dinner reservations. The name of the Dinner guest speaker will also be announced at that time.

National Meetings Calendar

July 12–14	Annual Summer Meeting, Los Angeles
December 16	Wright Brothers Lecture, Washington, D.C.
Jan. 29–31, Feb. 1, 1951	Nineteenth Annual Meeting, New York

N.A.C.A. Observes 35th Anniversary

Members of the National Advisory Committee for Aeronautics, past and present, gathered in Washington on April 20 to review aviation progress since 1915 when the N.A.C.A. was established. The occasion marked the 35th anniversary of the first meeting of the Committee.

Captain Holden C. Richardson, U.S.N., N.A.C.A.'s first Secretary, was among those present. He is one of two surviving original members of the Committee. The other, Dr. William F. Durand, H.F.I.A.S., now living in retirement at Palo Alto, Calif., was unable to attend. John F. Victory, M.I.A.S., first employee of the N.A.C.A., was also present in his capacity as Executive Secretary of the organization.

Progress made since the N.A.C.A.'s first meeting, held April 23, 1915, was reviewed informally by Dr. Hugh L. Dryden, H.F.I A.S., Director. "The first annual report spoke of the future of aeronautics 'involving developments of which today we barely dream'," he observed. "Long since, that prediction has come true, but in 1950 there is reason to discuss the future of aviation in the same terms, 'involving developments of which today we barely dream'."

Presiding at the meeting was Dr. Jerome C. Hunsaker, H.F.I.A.S., N.A.C.A. Chairman. Mention was made of the fact that N.A.C.A. *Report No. 1* was from the Massachusetts Institute of Technology and that the first of the report's two sections was written by Dr. Hunsaker.

Former N.A.C.A. members present at the meeting included Vice Adm. Emery S. Land, U.S.N. (ret.), F.I.A.S.; Major Gen. Henry C. Pratt, U.S.A.F. (ret.); Hon. Eugene L. Vidal, M.I.A.S.; Dr. Harry F. Guggenheim, Honorary Member, Member, and Benefactor of the Institute; Hon. William P. MacCracken, Jr., M.I.A.S.; Dr. Charles G. Abbot; Vice Adm. Aubrey W. Fitch, U.S.N. (ret.); Dr. Lyman J. Briggs, F.I.A.S.; Rear Adm. Lawrence B. Richardson, U.S.N. (ret.), F.I.A.S.; Rear Adm. Leslie C. Stevens, U.S.N.; Hon. William A. M. Burden, Member and Benefactor of the Institute; Vice Adm. Donald B. Duncan, U.S.N.; Gen. Carl Spaatz, U.S.A.F. (ret.); Dr. Vannevar Bush; and Major Gen. Edward M. Powers, U.S.A.F. (ret.).

Boeing Studies Turboprops for Stratocruisers and Stratofreighters

Turboprop power plants for the Stratocruiser and the U.S.A.F. C-97A Stratofreighter are under development at Boeing Airplane Company in Seattle. Boeing engineers estimate that they could have a turboprop version in the air in less than 1 year's time. Modification of the existing types is expected to be relatively simple, and the principal changes would be made in the engine nacelles in order to capitalize on the smaller diameters of the gas-turbine engines.

▶ **Weight-Saving**—The turboprop installation would weigh about 25 per cent less than the piston-engine installation, with the result that some 1,000 additional gallons of fuel could be carried. Design studies have already been made on aircraft powered with Allison XT-40-A gas turbines. Advantages sought after in a gas-turbine installation include greater operating altitudes, higher speed, heavier gross weights, increase in ton-miles of pay load per hour, reduction in runway length, more comfort for passengers, and easier maintenance.

Pneumatic System Provides Auxiliary Power for Convair XP5Y-1

One of the outstanding features of the 60-ton Navy Convair XP5Y-1 turboprop patrol plane (see cover) is the pneumatic auxiliary power system developed by AiResearch Manufacturing Company under sponsorship of the Navy Bureau of Aeronautics and Consolidated Vultee Aircraft Corporation.

▶ **Reliable Starting**—Use of the pneumatic system provides: independent operation of necessary aircraft accessories when the main turbine power plants are idle; an accessory power source in flight which maintains a constant speed regardless of main engine speed or varying accessory load; and an air-borne self-starting system for turbine-propelled aircraft which is capable of an unlimited number of self-starts without aid from any ground source of power.

The AiResearch pneumatic system broadens the operational possibilities of turbine-propelled aircraft by making them completely independent of ground power units. In the AiResearch system, air is compressed by two small gas-turbine compressors and is carried through ducting to the two air-turbine alternators and the four air-turbine starters. The alternators may be located where most convenient, and the starter units are coupled directly to the main engines. The gas turbines may be located almost anywhere in the airplane.

American Steel & Wire Joins I.A.S.

The American Steel & Wire Company, subsidiary of United States Steel Corporation, recently became a Corporate Member of the Institute. Since its first mill was built in 1831, this company has provided wire and

Re *Aeronautica*

Several inquiries received about *Aeronautica* indicate that not all I.A.S. members are familiar with the purpose and availability of this publication. Here are a few pertinent facts.

While *Aeronautica* was designed to serve Historical Associate members specifically, it is available to *all* I.A.S. members, regardless of grade, at the subscription price of $1.00 per year. (The subscription price to nonmembers is $2.00 per year.)

Aeronautica carries articles and items of interest to historians and collectors of early aviation materials and is published quarterly. Back copies of most of the four issues published during 1949 are still available.

The January-March and April-June issues for 1950 are immediately available and may be obtained by sending subscriptions directly to:

Aeronautica
Institute of the Aeronautical Sciences
2 East 64th Street, New York 21, N.Y.

wire products for many phases of American transportation, and its activities have played a large part in industrial and military development.

American Steel & Wire Company has also served the aviation industry for many years. The company provides aircraft control cables, electrical wire, stainless steel, stitching wire, bar stock, springs, and other miscellaneous items. It also manufactures welded wire fabric for concrete runway reinforcement, cyclone fencing, wire rope for utility purposes, and electrical cables for lighting and electronic aids.

In conjunction with the almost 120 years' experience that the company has had in making steel and wire, it has also developed extensive research facilities that not only are constantly striving to better current products but also are doing advanced research on metallurgical problems confronting the aircraft industry.

The main offices of the American Steel & Wire Company are located in the Rockefeller Building, Cleveland 13, Ohio. Other offices are situated in Chicago, New York, and all principal cities of the U.S.

Northrop Announces New Officers

The Board of Directors of Northrop Aircraft, Inc., during a special meeting, elected a new member and elevated additional company officers to new positions.

John W. Myers, M.I.A.S., Northrop Vice-President in Charge of Customer Relations, was elected a member of the Board to replace C. N. Monson, who resigned in December. Kenneth P. Bowen, M.I.A.S., formerly Assistant Vice-President in Charge of Manufacturing, was named Vice-President in Charge of Manufacturing, replacing B. G. Reed, M.I.A.S., who resigned earlier this year. Other appointments were Roland J. Pagen, Treasurer and Vice-President and Director of Finance and Accounts, and George T. Johnson, Controller.

Gifts to the Institute Collections

W. A. M. Burden added 395 issues of aeronautical periodicals to his previous generous gifts.

Three boxes of technical periodicals and reports published from 1930 to about 1942 on aerodynamics, materials, and meteorology were received from the University of Akron through the courtesy of Dr. Paul O. Huss and Miss Dorothy Hamlen. Publications from the United States, China, England, Germany, and Japan were included. Periodicals and reports were received from the Eclipse-Pioneer Division, Bendix Aviation Corporation, through the courtesy of Miss Mildred M. Baker.

Additional gifts were received from the Air Transport Association of America; American Institute for Research; Australian Scientific and Industrial Research Organization; Associated Aviation Underwriters; Bell Aircraft Corporation; Boeing Airplane Company; British Joint Services Mission; British Messier, Ltd.; Dr. G. Broersma; California Research Corporation; Continental Motors Corporation; Cornell Aeronautical Laboratory, Inc.; Douglas Aircraft Company, Inc.; Evans Research and Development Corporation; General Electric Company; Institut für Aerodynamik (Zürich); Kollsman Instrument Division, Square D Company; The Johns Hopkins University; Mrs. Bella C. Landauer; Lockheed Aircraft Corporation; Massachusetts Institute of Technology; Museum of the City of New York; Oregon State Board of Aeronautics; Princeton University; Schweizer Aircraft Corporation; Scott Aviation Corporation; Shell Oil Company; Texas Agricultural and Mechanical College; and the Urban Land Institute.

Reports and documents were received from the following Government agencies: U.S. Air Force; Army Ordnance Department; Bureau of Mines; Civil Aeronautics Administration; Civil Aeronautics Board; Coast and Geodetic Survey; Department of Agriculture; Forest Products Laboratory; Immigration and Naturalization Service; National Advisory Committee for Aeronautics; National Bureau of Standards; Navy Bureau of Ordnance; Research and Development Board; State Department; U.S. Weather Bureau; and Senate and House special committees.

NORTHROP C-125 RAIDER—U.S.A.F.'S NEWEST LIGHT TRANSPORT

Fixed landing gear, rugged construction, three-engined dependability, reversible-pitch propellers, and a high-lift wing employing maximum-span flaps combine to provide ability to land and take-off in short distances from rough terrain. Northrop Aircraft, Inc., is building 13 assault versions and ten Arctic rescue versions of the Raider, which can carry over 8,000 lbs. of cargo or 32 passengers. Photograph shows rescue version flying simulated mission along Pacific coast.

I.A.S. Newslines

▶ Operations Coordinator . . . **Otto E. Kirchner,** F.I.A.S., has been appointed Director of Operational Engineering, American Airlines, Inc., with offices in New York. He will coordinate American's aircraft operating and performance problems in relationship with Governmental agencies. Mr. Kirchner has been with American Airlines since 1928 and most recently was Director—Engineering, Tulsa, Okla.

▶ Professorship . . . **W. Prager,** A.F.I.A.S., served as Walker-Ames Professor of Applied Mechanics at the College of Engineering of the University of Washington in Seattle for the period May 1 to May 21.

▶ Municipal Appointment . . . **Bernard L. Prenovich,** A.F.I.A.S., is now City Engineer, Hawthorne, Calif.

Corporate Member News

• Actuator Redesigned . . . **Airborne Accessories Corporation** has completely redesigned its "TRIM TROL" electric d.c. Rotary Actuator in a more compact unit that weighs 2¼ lbs. and is available in two mounting styles. The standard gear ratio produces 350 in.lbs. operating torque through 180° maximum rotation. Static capacity exceeds 1,500 in.lbs. Unit complies with all applicable aircraft specifications and incorporates zero backlash output, magnetic brake, built-in externally adjustable limit switches and potentiometer, and radio noise filter. Accurate and sensitive positioning or electrical synchronizing controls are available. Provision for mechanical synchronizing in pairs is optional. The units are also available for operation on 110 volts a.c. for industrial applications.

• Industrial Safety . . . In a report of industrial injuries for 1949 submitted to the National Safety Council, **American Overseas Airlines, Inc.,** showed disabling injury rates substantially below those prevalent in industry in general as well as in the air-transport field. A.O.A. reported a frequency rate of 7.01 lost-time injuries per 1,000,000 man-hours worked and a severity rate of 0.11 days lost per 1,000 man-hours during 1949. In 1948, the latest year for which the National Safety Council has released industry-wide figures, the air-transport industry reported a frequency rate of 15.05 and a severity rate of 1.88. A.O.A.'s severity rate of 0.11 is 39 per cent better than the 0.18 rate of the communications industry, which the National Safety Council rates as the safest of all industries. American Overseas Airlines' flight safety record extends over nearly 3½ years and includes some 600,000,000 passenger-miles flown without a fatal accident.

• Beechcraft Propeller Rights . . . **Beech Aircraft Corporation** has granted exclusive rights to Flottorp Manufacturing Company for the manufacture, sales, and servicing of the ROO2 and ROO3 Series Beechcraft Controllable Propellers for Continental-powered 65- and 85-hp. aircraft. These propellers, now available under the trade name of Flottorp Controllable Pitch Propellers, will have the Flottorp "Armor Coated" blade to eliminate erosion wear and keep moisture from the core. The mechanical control will be the Beech-Roby design that has proved successful and trouble-free in actual service. A factory service plan for the reconditioning and "Armor Coating" of the ROO2 and ROO3 blades now in service has been set up by Flottorp . . . A new U.S.A.F. contract for the first three YT-34 all-metal two-place military trainers has been awarded to Beech Aircraft Corporation. Delivery of these aircraft is scheduled for June and July. The YT-34 Beechcraft is expected to produce performance equivalent to that of previous trainers of three times its horsepower but to do so at only about one-third of the cost per flying hour. The new trainer, known originally as the Beechcraft Model 45 Mentor, is similar in appearance to the Bonanza.

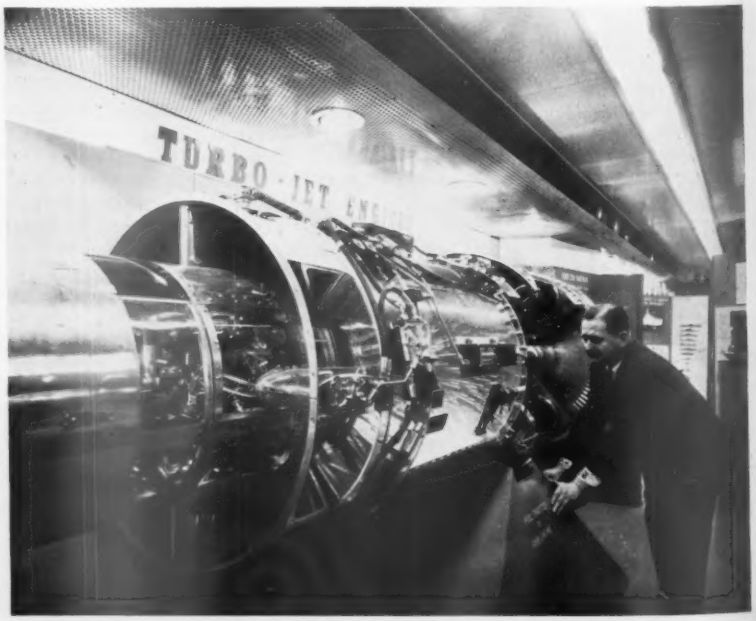
• Deliveries Completed . . . With the delivery of its tenth Stratocruiser to B.O.A.C. late in March, **Boeing Airplane Company** completed its final airplane under contracts that called for 55 commercial models of the transport. Although delivery of this airplane ends commercial airplane construction at Boeing for the time being, U.S.A.F. C-97 Stratofreighters of similar design are still being produced regularly at Seattle . . . Boeing's Model 502 175-hp. 200-lb. experimental gas turbine has successfully passed road tests in a 10-ton truck chassis with a 35-ft. trailer attached. Boeing stated previously that use in small aircraft or use as an aircraft auxiliary power plant were some of the wide-range duties for the which the Model 502, under development for the Navy Bureau of Ships, should prove adaptable. The gas-turbine research group at Boeing now has the status of an independent department, following the appointment of Jay Morrison as Manager of the Gas Turbine Project.

• First Postwar Profits . . . **Consolidated Vultee Aircraft Corporation** showed an operating profit of $3,713,156 for the fiscal year ended November 30, 1949. This was the first profitable year since 1945 and compared with a net loss of $11,978,795 for 1948. Backlog of unfinished work approximated $207,000,000 with $20,000,000 for the Navy, less than $1,000,000 for commercial customers, and the remainder for the Air Force. All but two of the Convair-Liners built for air lines have been delivered. Orders for procurement of 75 additional B-36 airplanes have now become firm contracts. On the basis of further A.F. procurement of these airplanes, the Fort Worth plant is expected to be kept active for several years to come. B-36 parts and assemblies are also being manufactured at San Diego. A contract has been received for 36 planes of a military version of the Convair-Liner, and orders for twelve more additional aircraft of this type, designated the T-29, have been placed. The first plane has been delivered to the Air Force . . . Convair has reported a profit of $2,934,496 for the first quarter ended February 28. These earnings included a nonrecurring amount of approximately $2,200,000 by reason of a change in the company's method of accounting at the beginning of the current fiscal year. The accounting change involves the timing of taking income into the books of account from cost-plus-fixed-fee contracts . . . Approximately 3,000 more employees will be added to Convair's San Diego Division payroll to modify B-36 bombers. The program calls for installation of four jet engines on B-36B models, converting them to B-36D bombers. Employment in the Fort Worth Division is also expected to rise.

• For Airframe Manufacturers . . . **Elastic Stop Nut Corporation of America** has announced a new extra-high lightweight all-metal cap for certain ESNA hex and anchor nuts. The cap height on the new-type K3 cap nuts is sufficient to ensure full clearance for AN-3 and AN-4 bolts or AN-509 screws. The cap also forms a pressure seal against external or internal liquid and gas pressures of 80 lbs. per sq.in.

GENERAL ELECTRIC'S "MORE POWER TO AMERICA SPECIAL"

This cutaway model of the J-47 turbojet engine is but one of some 2,000 items contained in the gigantic "display kit on wheels" launched by G-E last month. Containing a complete range of products for the production, distribution, and utilization of electric power, this 10-car exhibit train introduces a unique and progressive concept of industrial marketing practices.



minimum, affords protection against vibration, and maintains exact adjustments, even after repeated reuse.

• Just a Minute . . . A new recording camera for photographing the screen of a cathode-ray oscilloscope and producing a print for engineering study within 1 min. has been announced by the **Fairchild Camera and Instrument Corporation.** Designated as the F-284 Fairchild-Polaroid Oscilloscope Camera, the unit is an adaptation of the Polaroid-Land Camera. Prints are available for immediate evaluation without the need for darkroom processing. A two-position overcenter shift makes it possible to make two recordings on one print—for example, when it is desired to record the difference in performance "before" and "after" a change has been made. The Fairchild-Polaroid Oscilloscope Camera is designed for use with any standard 5-in. cathode-ray oscilloscope. Print size is $3^1/_4$ by $4^1/_4$ in. with the two recorded images reduced by a ratio of only 2 to 1 from the original trace . . . A net profit of $270,297 was earned by the corporation in 1949. This compares with a net of $151,425 in 1948, an increase of 78 per cent. Consolidated sales in 1949 were $7,704,022 as compared with $6,637,814 in the previous year, an increase of 17 per cent. The substantially higher rate of increase in earnings reflects "the slow and costly recovery from the strike of 1948 at the main Jamaica plant." The company started 1950 with unfilled orders amounting to $7,618,369 as against $5,808,598 at the beginning of 1949. Current assets at the year-end are listed at $5,176,776 as compared with current liabilities of $1,343,743, a ratio of 3.8 to 1.

• Financial Progress . . . Earnings of **Fairchild Engine and Airplane Corporation** for 1949 were $1,575,328 as compared to 1948 earnings of $1,211,563. Financial items highlighted in the annual report included: sales of $48,101,453; unfilled orders at year-end of $80,100,000; a previously announced 35-cent dividend, largest in the corporation's history; and an increase in net working capital to $14,687,053 as against $12,705,948 for 1948.

• Protection for B-29 . . . At request of the U.S.A.F., **Walter Kidde & Company, Inc.** is preparing detail drawings and specifications for conversion of present fire-extinguishing equipment on all B-29's to handle CB (monochloromonobromethane). B-29's are now equipped with Kidde carbon-dioxide systems for engine fire protection.

• Cabin Pressure Control . . . **Kollsman Instrument Division, Square D Company,** has proposed a small, lightweight, and completely electric cabin pressurization system for use on pressurized aircraft of all performance ranges. The proposed equipment will operate on a new principle of a definite relationship between the altitude at which a plane is flying and the pressure maintained within the cabin of the aircraft. The cabin pressure will decrease with increase in altitude in the ratio that will provide optimum passenger comfort. While the system is proportioning the cabin pressure in relation to altitude, it also will take cognizance of the structural strength of the airplane for safety and the rate of cabin pressure change for comfort. Completely automatic, it will also provide modifying manual controls to meet unusual flight conditions. For reliability, all pneumatic controls, potentiometers, and sensitive contacts will have been eliminated in favor of an inductive electrical system, which will operate on 400-cycle a.c. power. The proposed system makes use of three Kollsman Synchrotel instruments that will measure the cabin absolute pressure, the outside altitude pressure, and the pressure difference between them. The simplicity of the components will assure long life and low-cost easy maintenance. Although the system itself is new, its component parts are standard Kollsman products.

UNDERWING TANKS BOOST THUNDERJET'S RANGE

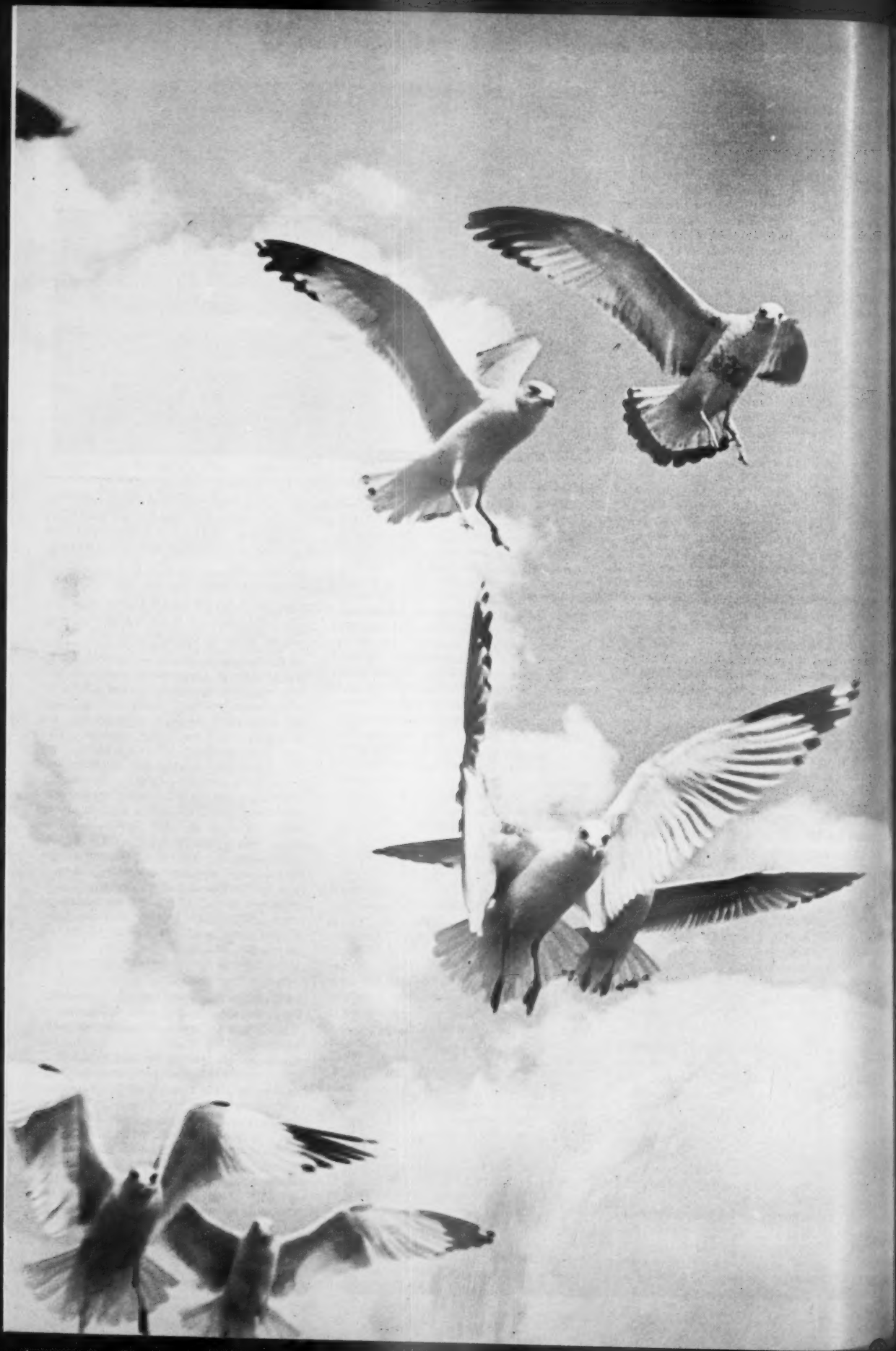
Combat range of the F-84E Thunderjet, manufactured by Republic Aviation Corporation, has been extended from 850 to well over 1,000 miles by the addition of two 230-gal. fuel tanks mounted on bomb shackles under the wing. The underwing tanks are interchangeable with those at wing tips. Bomb shackles, as well as tanks, may be dropped to leave the airplane in clean configuration for combat.

• New Lear A.D.F. . . . A new Model ADF-12 Automatic Direction Finder has been announced by **Lear, Inc.** Consisting of a tuner, amplifier, azimuth indicator, and loop assembly, the complete unit weighs 18 lbs. and is all electric in operation. With no flexible shafting between loop and indicator, installation is simplified, response is smoother, and accuracy is greater. Any broadcast, radio-range, control-tower, or Coast Guard radio-beacon station may be used as a homing station. The ADF-12 meets U.S.A.F. and C.A.A. design requirements for use in jet, transport, executive, liaison, and personal aircraft . . . The company's operations for 1949 resulted in a net profit of $510,496.59 on sales of $7,368,000. This compares with an operating loss of $702,551.38 on sales of $5,326,000 for 1948. The 1949 profit is 6.94 per cent of sales and reflects a 38.3 per cent increase in sales volume over 1948. Unfilled order backlog at year's end was $7,200,000 as compared with $4,269,000 at the end of 1948. The year-end backlog, as well as the 1949 sales, is the largest since the war period. With current assets of $3,320,404.91 and current liabilities of $807,714.48, working capital amounts to $2,512,690.33.

• Production Increase . . . In 1949, **Lockheed Aircraft Corporation** delivered 505 airplanes and spare parts as compared with 373 planes in 1948. Deliveries included 17 Constellations—ten commercial, six Air Force, and one Navy versions. The Air Force received 437 other planes and the Navy 51. Of the 505 airplanes delivered, 447 were jet-powered. Spare-part sales amounted to $22,161,000, an increase over the $20,390,000 sold in 1948 and more than one-sixth of total 1949 sales. Unfilled orders totaled $229,746,000, an increase over the $195,901,000 reported for 1948. Sales of airplanes, parts, and services by Lockheed and wholly owned subsidiaries were $117,667,000 as compared with $125,621,000 for the previous year. Consolidated net earnings were $5,491,000 as against $6,239,000 for 1948. Eighty-three per cent of sales were military, and 17 per cent were commercial.

• Marform Available Abroad . . . The Marform metal-forming process developed by **The Glenn L. Martin Company** is being introduced by The Loewy Engineering Company Limited of London, England, in the United Kingdom, the British Commonwealth, the Continent, and other export territories. Complete Marform presses and equipment for converting existing presses to the Marform Process will be supplied by Loewy Engineering, which intends to build the equipment in their plant at Light Machines Ltd., Yeovil. Hydropress, Inc., New York City, is the manufacturer and seller of Marform units in the U.S. The Martin company will continue to make available the surplus capacity of its own Marform

(*Continued on page 81*)



Editorial

—— "And Why Can't I?"

Speed, speed, and more speed has been the constant theme of I.A.S. and other scientific meetings of the past few years. "*Sonic barrier*," "*supersonics*," and "*hypersonics*" have been dinned in our ears to the point that no author would dare omit them from a paper for fear of being out of date. The corollary is a cry for power and more power. Whip up the horses! Pour on the coal! Then go roaring about with earth-shaking (and soul-satisfying) bursts of flame and smoke that dwarf the ancient thunderbolts of Jupiter and Vulcan.

And all the while, the natural fliers, the birds, go about their business easily and silently—doubtless wondering what the fuss is all about.

Perhaps it would be a useful thing to start thinking more seriously about bird-flight. Of course, a "supersonic" bird would lose his feathers before you could say "boundary layer," but certainly we must admit that there are things that any respectable "subsonic" bird takes for granted that are beyond our ken. There must be easier ways of flying than by being shot out of a gun or by being propelled by blasts of superatomic power.

This is no argument that we should go back to Darius Green and forget all we have learned in the past 45 or 50 years or that we should abandon in any degree our researches toward maximum performance of aircraft as we know them. We only suggest that some obvious things may have been overlooked as we have rushed along.

A few people, here and there, have been keeping an eye on the birds. Excluding the "screwball" fringe (the lads who still appear occasionally in the newsreels flapping aimlessly about with homemade canvas wings), you will find serious thought on the subject. Bill Stout's work on the mechanics of bird and insect flight is well known to those engaged in aviation. James Fitz-Patrick, in New York, has been a persistent ploughman in the field. He has made an extensive search of the literature and has compiled what is probably the best bibliography available on natural flight. (This may be seen in I.A.S. Libraries.) He has built a series of extraordinary working models of bird wings which reveal much of the heretofore unknown elements of flapping wing behavior. Recently, Prof. August Raspet, of Mississippi State College, has been studying the flight performance parameters of birds by following their flight in a sailplane. Other researchers are investigating the metabolic processes of birds to try to discover their sources of energy for long flights. New photographic techniques are being applied in studies of bird flight under many conditions.

These are but a few scattered beginnings. We would like to see someone pick up the clues and do some really serious work on the subject. It may not win any wars in the 1950's, but it might eventually pay off. *Qui le sait?* Let us not, therefore, look down our noses at our feathered friends because they cannot crack the sonic barrier. They have been flying for some time. They know something about it that so far has escaped us. After all, we *might* learn something new by taking another look.

S. P. J.

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Propulsion Analysis for Long-Range Transport Airplanes

ALEXANDER KARTVELI*
Republic Aviation Corporation

IN DISCUSSING THE REQUISITES of air transportation, it has always been my opinion that there is one basic parameter—*speed*. Outside of its practical importance, the factor of speed has a psychological value, and its influence on profit and cost cannot be evaluated by mathematical formulas. The importance of speed becomes much more pronounced in the case of long-range transport airplanes, where, in addition to psychological advantage, the saving of time is the most attractive feature. Therefore, we should exert all our efforts to the attainment of greater speeds within practical limits of safety and economy.

As we all know, the postwar era has brought into existence several new propulsion devices that offer interesting prospects for increasing speed. How can these new propulsion devices at our disposal affect the performance of long-range transport airplanes, and what improvements in speed at a given range can be obtained?

Three possible power-plant versions are now available for this type of aircraft: reciprocating engine compounded with turbosupercharger; turboprop; and pure jet. Each type has its advantages and defects, and each is now being considered by aeronautical engineers.

The problem of appraising the fitness of a power plant for a given type of airplane is complex when treated in its generality. It not only involves factors depending upon the engine but also those of the airplane and outside conditions. Factors such as engine size and weight, specific fuel consumption, cooling, propeller efficiency, airplane weight and useful load, aerodynamic characteristics of the wing, compressibility, structural considerations of aeroelasticity, etc., should all be considered in their respective relation. Because of the multiplicity of factors, a general analytical study becomes so involved that the conclusions reached are of academic and general character. The analysis of the relative merits of various power plants, therefore, should be conducted not from the academic, but from a purely engineering, point of view in the light of the present state of the art, available methods and technique, and equipment that exists or which will exist in the near future.

In conducting this analysis, we first considered a long-range transport airplane equipped with four turbosupercharged reciprocating engines. We assumed this airplane to be designed in accordance with modern technique, using the latest available equipment and complying with all necessary requirements. For this airplane, curves of range versus cruising speed were computed at various altitudes. Studies were then made of how these curves would change if the reciprocating power plant were replaced first by a turboprop installation and then by a pure jet power plant. To make this comparison valid, the pay load, as well as the fuselage and its contents, was left the same in all cases. Certain small adjustments were made, however, in the thickness and area of the wing to bring the aerodynamic qualities of the wing in accordance with the speed attainable with a given power plant. In making this adjustment, the volumetric capacity of the wing was kept the same in each case, so that the total volume of fuel carried remained unchanged. We believe that this basis of comparison is rational. For the sake of clarity, however, we would like to explain this point in more detail.

In choosing the wing for a high-speed airplane, the thickness, aspect ratio, span, and a certain magnitude of area are first assumed to comply with necessary structural, weight, flutter, and compressibility requirements. A check is then made to make certain that such a wing meets auxiliary requirements of take-off, climb, maneuverability, landing, etc., when used with a given power plant. It is usually found that with modern power plants this requirement is not critical within the acceptable values of wing loading. This is because of the high horsepower at take-off which these power plants develop due to water injection in the case of reciprocating engines, inherent large horsepower of turboprop engines, and the use of afterburning in the case of pure jet engines. This requirement, therefore, does not affect the value of wing area. An analytical study of range versus cruising speed shows that, for the achievement of greater cruising speed without much loss in range, it is advantageous to keep the wing area rather small to reduce compressibility drag. It is, however, impossible to reduce the wing area to the desirable lower limit because of the necessity of having a given minimum volumetric capacity for fuel. Thus, the volumetric capacity becomes an important factor in determining the final value of the wing area. It is logical, therefore, that, in pursuing this analysis, wings with the same volumetric capacity should be considered in each case.

Presented at the Fifth Annual Flight Propulsion Meeting, I.A.S., Cleveland, March 24, 1950.

* Vice-President and Chief Engineer.

In this way, three airplanes of approximately the same size, carrying the same pay load, and having the same fuel capacity were obtained. The gross weight of these airplanes varies within reasonable limits, depending upon the conditions of each case. It is believed that the problem so treated will yield interesting practical results and will correspond to the actual case that confronts the industry now.

As a basic airplane of this type, we have chosen the Republic Rainbow, for which a large number of flight tests and wind-tunnel and theoretical investigations are available. Fig. 1 gives a view of this airplane in flight.

This airplane is a long-range transport carrying 40 passengers and six crew members, with a total pay load of 10,000 lbs. It has a mid-wing arrangement, with a wing area of 1,640 sq.ft., aspect ratio of 10, and an average thickness of approximately 15½ per cent. The buffeting limit is approximately 0.76 Mach Number. The wing has an available internal volume to carry 6,200 gal. of gasoline. With 10,000 lbs. of pay load and 6,200 gal. of gasoline, the gross weight of the airplane is 120,300 lbs.

The reciprocating engine power plant consists of four Pratt & Whitney R-4360 engines developing a take-off horsepower of 3,800 at sea level with water injection. Each engine is equipped with an exhaust-driven supercharger, which permits high cruising powers to be carried to 40,000 ft. The turbosupercharger is so arranged in the nacelle that the exhaust gases are ejected horizontally through the aft end of the nacelle, thus providing a certain amount of jet thrust.

For this airplane, curves of range versus cruising speed at altitudes of 20,000, 30,000, and 40,000 ft. were computed. It was assumed in these computations that 10 min. at normal rated horsepower were spent on the ground for warm-up, taxiing, and take-off. It was further assumed that the climb to cruising altitude was performed under optimum conditions of minimum fuel burned and maximum distance gained in the climb and that the reserve fuel allowance is 600 gal. of fuel. The horizontal distance covered in the climb was added to the computed level flight range, but no increase in range was taken because of the horizontal distance covered in the descent. Fig. 2 shows range versus speed curves at three altitudes for this reciprocating-engine version.

At each altitude, the horsepower of the engines was varied between maximum permissible cruising horsepower at that altitude and the minimum cruising power corresponding to the best value of miles per pound. Where applicable, the lower limit of cruising power was taken equal to the power that gave a rate of climb of 200 ft. per min. It is seen that the range-speed performance of this airplane improves considerably when the altitude increases. At 40,000 ft., a range of approximately 4,000 miles could be obtained at an average cruising speed of 400 m.p.h., while a range of 2,750 miles could be flown at a speed of 450 m.p.h. or a Mach

FIG. 1. Republic Rainbow.

Number of 0.67, thus giving a margin below buffeting limit of 0.1 Mach, or 66 m.p.h.

This airplane could, therefore, be used on transatlantic runs between New York and London with an average cruising speed of 400 m.p.h. and also on transcontinental New York to Los Angeles runs with a speed of 450 m.p.h.

We next studied the same airplane equipped with four Allison turboprop engines. Fig. 3 shows a view of this airplane in flight and illustrates the smaller nacelles attainable with this type of power plant.

In this study, we again assumed that the fuselage and contents remained unchanged—that is to say, pay load, passenger accommodations, and all the equipment and accessories necessary to operate and control the airplane are identical. The wing, however, while basically identical to the preceding case, has a longer average chord which brings its average thickness to 14 per cent or 1½ per cent thinner than that of the Rainbow. This change is accomplished by extending that portion of the leading edge which overhangs the front spar. Under this condition, the wing has an area of 1,750 sq.ft., a slightly smaller aspect ratio, and the same available volumetric capacity of 6,200 gal. Its critical buffeting limit for values of lift coefficient involved is increased from 0.76 to approximately 0.8.

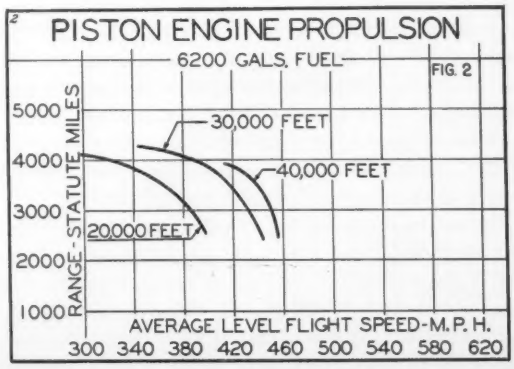
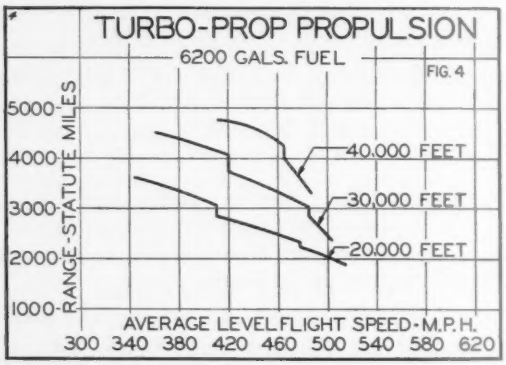


FIG. 3. Republic Rainbow equipped with four Allison turboprop engines.



Each turboprop engine is installed in a nacelle of 40-in. maximum diameter. The distance between the main spars of the wing is sufficiently large to permit the engines to be housed inside of the wing between these spars. Extension shafts protrude forward of the front spar and carry dual-rotation propellers. The engine air is admitted through two openings in the leading edge symmetrically located on either side of the nacelle. Because of the lighter weight of the turboprop engine and the absence of cooling equipment, such as intercoolers, oil coolers, various air inlets and ducts, the total weight of the power plant is considerably less than in the preceding case. A saving of 6,600 lbs. results from this interchange of power plants. Since the fuel capacity of the wing is the same as before, 6,200 gal. of kerosene could be used instead of gasoline, giving an increase of fuel load of 4,960 lbs. Allowing certain additional weight for wing reinforcement to take care of the longer leading edge and higher speed, the gross weight of the airplane becomes 119,400 lbs.

Curves of range versus velocity were computed for this airplane under the same assumptions as before. Fig. 4 gives these curves for the same altitudes of 20,000, 30,000, and 40,000 ft. In these computations, it was assumed that the r.p.m. of each engine varies between the value corresponding to full normal power and the value giving 60 per cent of normal power. Since the specific fuel consumption increases rapidly below 60 per cent of normal power, it was assumed that further reduction of power was accomplished by stopping one of the two siamesed engines in various nacelles. First two units and then four were assumed inactive. This explains the steps in the performance curves on Fig. 4. Numerical computations were based on re-rated values of power which will be available in the near future. As can be seen, the range increases with altitude, while the maximum possible cruising speed is obtainable at lower altitude. A maximum range of 4,750 miles at 410 m.p.h. can be obtained at 40,000 ft. At 20,000 ft., a cruising speed of 515 m.p.h. will give a range of 1,875 miles.

A transoceanic nonstop flight of 4,000 miles at 40,000 ft. will have an average cruising speed of 465 m.p.h., while a transcontinental run of 2,750 miles will take place at approximately 500 m.p.h. at 30,000 ft. In both cases, the margin below buffeting limit is approximately 0.1 Mach.

It is to be noted that propellers used in these computations are of existing types. It appears, therefore, that this combination does not involve the development of any new equipment.

The turbojet version of this airplane is shown on Fig. 5. Again, as before, the pay load, fuselage, and its contents remain the same. The airplane is, however, equipped with an entirely new wing. A sweptback wing having 35° of sweep and a thickness of 12 per cent was chosen. The wing has an area of 2,000 sq.ft., aspect ratio of 8, and can house the same 6,200 gal. of fuel. Its buffeting limit, within the values of lift coefficient considered, is estimated to be approximately 0.9 Mach. A structural penalty of 6,500 lbs. was assumed as the additional cost of this wing and was added to the gross weight of the airplane. Under these conditions, with kerosene as fuel, the gross weight of the airplane is 126,150 lbs.

The airplane is equipped with four recent type turbojet engines located in two underslung nacelles. Each

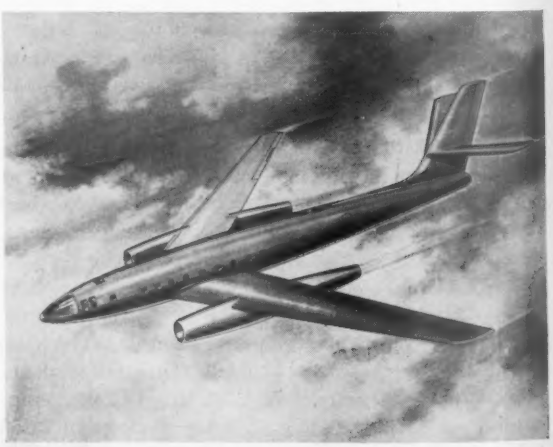
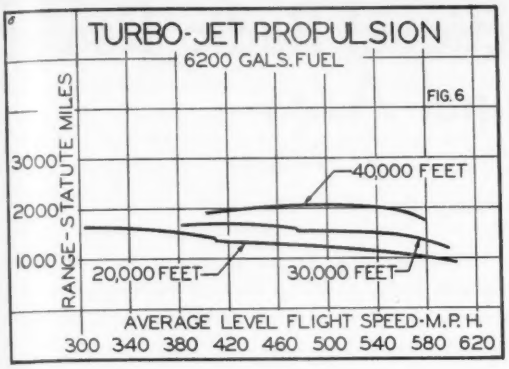
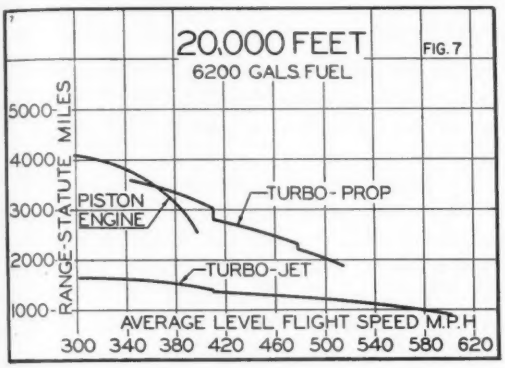


FIG. 5. Turbojet version of Republic Rainbow.





nacelle houses two engines, staggered one behind the other. The landing gear is also housed in the nacelles. Recent tests show that interference drag of an underslung nacelle can be considerably reduced if the boundary layer in the inboard wing nacelle intersection is bled away. The drag of this airplane was carefully computed, using recently available data. Curves of range versus speed at various altitudes were established under the same conditions as before. Fig. 6 shows these curves. Again, the range at a given speed increases with altitude, but the increase is of a much lesser amount than in the two preceding cases. A relatively constant range for wide variation of cruising speed is characteristic of jet-propelled airplanes. At 20,000 ft., a cruising speed of 580 m.p.h. with a range of 1,000 miles could be obtained. At 40,000 ft. a range of 2,000 miles corresponds to a cruising speed of 550 m.p.h. In both cases the margin below buffeting limit is approximately 0.1 Mach.

We are now in possession of sets of curves for each airplane and are in a position to make a comparison. Fig. 7 shows range versus speed curves for the three combinations at 20,000 ft. For lower speeds, the reciprocating engine has a slightly greater range than the turboprop. At 365 m.p.h., the range for both engines is equal, but beyond this speed the range of the reciprocating engine decreases rapidly and stays below that of the turboprop. The curve for the turbojet engine is considerably below the other two. The maximum attainable speed for the turbojet, however, is some 90 m.p.h. greater than that of the turboprop.

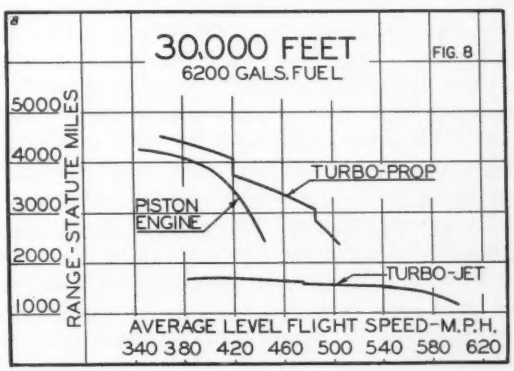
Fig. 8 gives similar curves for 30,000 ft. The turboprop curve is located entirely above that for the reciprocating engine, while the curve for the turbojet has shifted upward slightly. For a range of 3,000 miles, the cruising speed of the turboprop is some 50 m.p.h. faster than that of the reciprocating engine. The maximum speed of the turbojet is again approximately 90 m.p.h. faster than that of the turboprop, but for a much lower range.

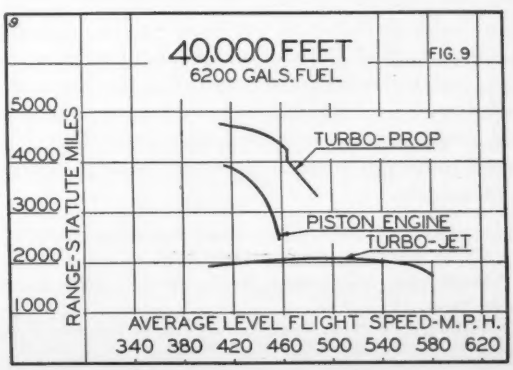
Fig. 9 shows the comparison at 40,000 ft. The curve for the turboprop has definitely assumed the highest position at all speeds within the capability of the engine. The reciprocating engine and the turboprop attain their maximum range at the same speed of 410 m.p.h. The range of the turboprop, however, is some 20 per cent greater. For equal range, the cruising speed of the turboprop airplane is approximately 45 m.p.h. greater than that of the reciprocating engine. The curve for the turbojet has again taken a slight upward shift and gives practically the same range of 2,000 miles for speeds from 420 to 570 m.p.h.

It is to be remembered that only existing design propellers were considered in the cases of the turboprop and reciprocating engine. The use of supersonic propellers will undoubtedly extend the speed of the turboprop combination.

This study was conducted on an unbiased basis with no preferences to any of the three combinations. While lacking generality, it corresponds to a modern, medium-size transport airplane that brings it into the scope of the problem now confronting the industry. The final

(*Continued on page 69*)





A Precision Omnidirectional Radio Range for the Terminal Area

JOSEPH LYMAN* and GEORGE B. LITCHFORD†

Sperry Gyroscope Company

Introduction

The radio and aviation sciences, in recent years, have grown so close together that aviation could not conceive of regular operations without radio. This dependence on radio for all-weather flight will be even greater as improved radio aids develop. It therefore now seems entirely fitting that a report describing the first phases of the development of a new radio aid should be presented. Such an early presentation is made so that (1) the operational requirements as established by the other aeronautical sciences may guide this development in the future and (2) realistic future operational plans may be built upon knowledge of a new radio technique.

This paper reports on the development of a type of radio system that is capable of providing the azimuth element of a polar-coordinate guidance system upon which air traffic in the terminal area may be controlled in the future. This element is called an omni-azimuth range because azimuth information is sent in all azimuth directions to all using aircraft. It has been undertaken by the U.S. Air Force not only because of its interest in the combined military-civil airways problem but also because it recognizes the necessity to explore possibilities that may yield tactical superiority in the future.

There are two basic problems immediately confronted when a development of the sort to be described is undertaken. The first is to determine the operational requirements, and the second is to see how these requirements can best be met in practice. Of the two, determination of the operational requirements is the more difficult. It is possible that future operational requirements have not been properly assessed; the evaluation of the problem may have been either over- or underestimated. The equipment development has, as yet, reached only a small percentage of its design objectives. Nevertheless, it is being described at this time because it is hoped that the presentation of this paper to the Institute of the Aeronautical Sciences will result in securing criticism that will more accurately define the limits of the requirements. Potential users of this type of device will derive a better understanding of what they may expect in the future and so be better prepared to employ such devices.

Presented at the Instrument Session, Eighteenth Annual Meeting, I.A.S., New York, January 23–26, 1950.

* Engineering Department Head, Aircraft Radio Research Department.

† Engineering Section Head, Aircraft Radio Research Department.

An immediate and important problem susceptible to analysis is the civil and tactical requirements for the terminal area. Therefore, only this specific subject will be treated in this paper.

Operational Requirements for the Terminal Area

Before discussing the techniques of obtaining a high-accuracy omni-azimuth range, it would be well to discuss certain operational requirements that will make such a system necessary.

These requirements can best be stated by setting up the criteria for a theoretical terminal area using a polar-coordinate guidance system and seeing where the omni-azimuth system fits into the picture. In setting up these criteria, we will discuss only the landing operation. It is recognized that in any airport the landing and take-off operations are interspersed and that the two cases cannot be separated. However, landings are considered a more difficult task, both operationally and technically, than take-offs, and therefore this analysis has been confined to the landing problem.‡

Assumptions and Criteria

Fig. 1 illustrates a typical terminal area with the final approach path and the multiple tracks which feed

‡ The analysis of interspersed landings and take-offs is a more complex problem but this will not be treated in this paper.

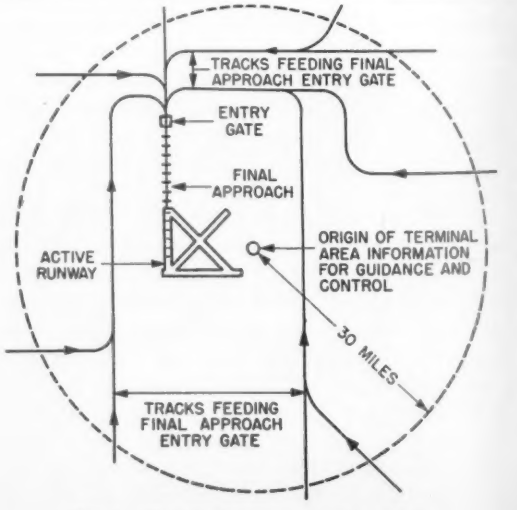

TRACKS FEEDING FINAL APPROACH ENTRY GATE
ENTRY GATE
FINAL APPROACH
ACTIVE RUNWAY
ORIGIN OF TERMINAL AREA INFORMATION FOR GUIDANCE AND CONTROL
30 MILES
TRACKS FEEDING FINAL APPROACH ENTRY GATE

Fig. 1. Terminal area approach problem.

traffic to it from surrounding en-route systems of guidance and control. In this example, it is assumed that the airport terminal area is circular, with a fixed radius, and that somewhere near its center is an airport with one active runway to which air traffic is fed. Before deriving the criteria of the traffic control system, two assumptions must be made:

Assumption (*1*).—The final approach speed along the approach path to the runway shall be 120 m.p.h. (ground speed).

Assumption (*2*).—The design (or maximum) capacity of the system shall be 120 aircraft landings per hour. At the assumed approach speed and landing rate, aircraft are spaced at intervals of 1 mile or 30 sec. in flying time.

On the basis of these assumptions, certain criteria can be set up. However, before stating these criteria, it is necessary to define what is called the "Entry Gate." In order to aid the analysis of traffic flow, a fictitious small box or entry gate is drawn at the beginning of the final approach path. The dimensions of this box are the positional accuracy of the system as stated in Criterion (1). The box is established to act as a metering device to measure the flow of traffic. It is placed at the beginning of the final approach path because it is at this point that all the precise control requirements must be met in order to achieve the assumed landing rate while still maintaining the necessary standards of safety. (See Fig. 2.)

Criterion (*1*).—The positional accuracy of the system—i.e., the accuracy to which both the ground controller and the pilot know the instantaneous position of the aircraft—must be within ±250 ft. along the track of the aircraft and ±250 ft. to the right and left of the track, or 500 ft. square. If this positional accuracy is not obtained, the assumed landing rate will not be met. Altitude is also a consideration, but it is not analyzed at this time, since it does not directly affect the omni-azimuth system.

Criterion (*2*).—In order to maintain a time spacing of 30 sec. between aircraft on the final approach, a time schedule must be established. Aircraft must pass through the entry gate to a scheduled accuracy of ±3 sec.

Criterion (*3*).—A heading accuracy of ±5° is required when passing through the entry gate to keep subsequent bracketing to a minimum.

Criterion (*4*).—The approach ground speed must be accurate to within ±2 per cent of the assigned approach ground speed. If 120 m.p.h. is used, the allowable variation is ±2.4 m.p.h.

Criterion (*5*).—The radius of the control zone must be approximately 30 miles.

Discussion of Assumptions

Approach Speed.—The choice of an approach speed of 120 m.p.h. does not require much explanation. It was chosen as typical for modern aircraft and because it

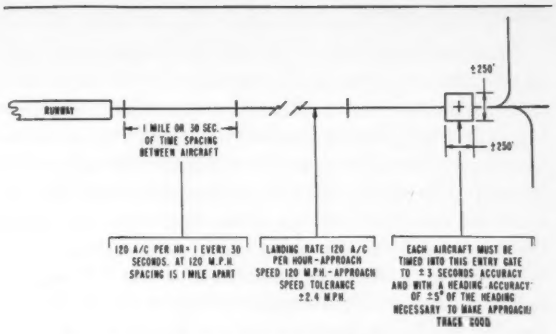

RUNWAY
1 MILE OR 30 SEC. OF TIME SPACING BETWEEN AIRCRAFT
±250'
±250'
120 A/C PER HR = 1 EVERY 30 SECONDS AT 120 M.P.H. SPACING IS 1 MILE APART
LANDING RATE 120 A/C PER HOUR - APPROACH SPEED 120 M.P.H. - APPROACH SPEED TOLERANCE ±2.4 M.P.H.
EACH AIRCRAFT MUST BE TIMED INTO THIS ENTRY GATE TO ±3 SECONDS ACCURACY AND WITH A HEADING ACCURACY OF ±5° OF THE HEADING NECESSARY TO MAKE APPROACH TRACK GOOD

FIG. 2. Analysis of conditions on final approach.

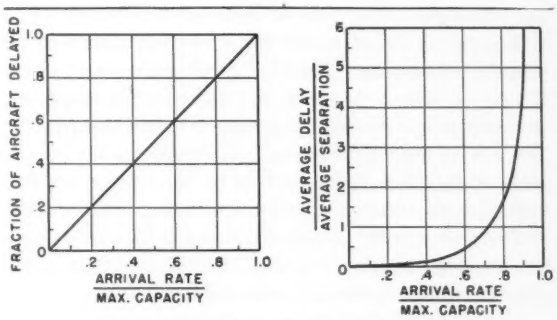


FIG. 3. Delays in the flow of air traffic.

produces convenient relationships. Changing the standard speed 20 or 30 m.p.h. does not materially affect the analysis. However, it should be noted that any variations by individual aircraft from the prescribed approach ground speed will cause reduction in the landing rate.

Maximum Landing Capacity.—The assumption of 120 landings per hour may seem high. However, it must be remembered that this is the designed *maximum* capacity of the system and is not the average arrival rate.

It is conceivable that a 120 landings per hour system would be used operationally at 85 or 90 landings per hour per runway. However, it is necessary to design the radio guidance system for the larger figure in order to ensure that the operational figure can be reached without intolerable delays being experienced by individual aircraft. Bowen and Pearcey[1] have shown that under normal operating conditions, landings, under a control system such as the one considered here, can never reach the maximum capacity of the system. A study of two curves that sum up their findings (Fig. 3) shows that, if the actual arrival rate becomes greater than approximately 80 per cent of the maximum capacity of the system, the average delay experienced by arriving aircraft becomes extremely large and almost all aircraft are delayed to some extent.

A designed maximum capacity even in excess of 120 landings per hour might be desirable, but this would require considerable replanning of most airports. The main point is that the guidance and control system must not be the limiting factor in the capacity of the airport.

Analysis of Criteria

Positional Accuracy.—The most important single part of this analysis is the positional accuracy of the system. The resolution of a navigation or guidance system is always better than its absolute accuracy. Good resolution is, of course, necessary in the guidance and control of aircraft in close proximity, especially when both aircraft are navigating on the same equipment and when traffic control instructions are based on the same navigation system. Thus, high definition of relative position between two aircraft (resolution) is essential for the prevention of air collisions. However, in order to perform the scheduling and prediction functions necessary to maintain a high landing rate, air position must be related to a ground coordinate system. Here, high resolution is not sufficient and the absolute accuracy of positional information becomes the governing factor. Therefore, whenever the term "accuracy" is employed in this paper, it is absolute accuracy that is meant.

Without sufficient positional accuracy, the ground speed of the aircraft can neither be determined nor controlled, and, consequently, the scheduling accuracy cannot be maintained. Losses in accuracy tend to increase the spacings at which aircraft can be operated safely and thereby decrease the landing rate.

The effects of inaccuracy in these parameters can be seen readily by a study of Fig. 4. The primary ambiguity due to the fact that the aircraft may be anywhere within a 500-ft. square is obvious. Next is the spacing error due to time-scheduling inaccuracy (i.e., the inaccuracy in the prediction of the time that the aircraft will pass through the entry gate). The criterion is ±3 sec. through the entry gate. A difference of 3 sec. flying time is roughly equivalent to 500 ft. at 120 m.p.h. This, added to the ±250-ft. positional tolerance, brings the inaccuracy along the flight track to ±750 ft.

The accuracy of the measurement of ground speed is strongly dependent on positional accuracy. If ground speed is to be measured to ±2 per cent, it is necessary to perform the measurement over a track that contains at least 25 elements of position (±250 ft. or 500 ft.). The resulting track is 12,500 ft. or approximately $2^1/_2$ miles long. Any necessary corrections in speed tend to lengthen the track, so that we may say that an aircraft can travel approximately 3 miles without realization by the pilot or the ground control that it is varying from the prescribed ground speed. During the 90 sec. it takes to cover this distance at 120 m.p.h., a basic error of approximately ±350 ft. can be accumulated simply because the ground speed cannot be measured more accurately than ±2 per cent or ±2.4 m.p.h. This error, added to the other spacing errors, brings the total inaccuracy along the flight track to ±1,100 ft. and can reduce the minimum spacing between two aircraft to approximately 3,000 ft. instead of the 5,280-ft. spacing planned.

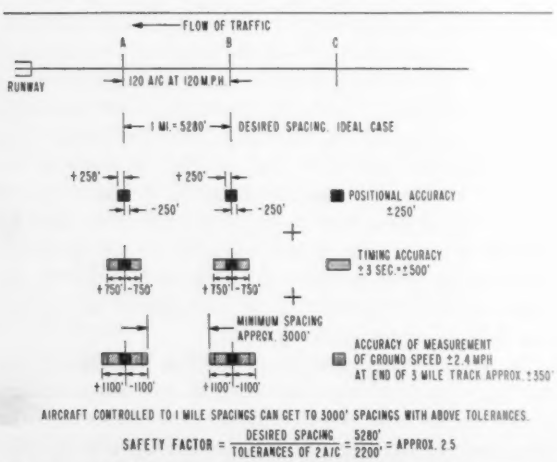


FIG. 4. Additive tolerances of two aircraft on final approach.

These additive tolerances along the final approach path indicate that a safety factor (desired spacing/tolerances of two aircraft) of approximately 2.5 to 1 is achieved (5,280/2,200).* Such a tolerance may or may not be acceptable. If it is desired to increase the safety factor, it would be necessary to: (a) decrease the landing rate, (b) increase the positional accuracy, (c) increase the scheduling accuracy, and (d) increase the ground speed measurement accuracy.

Radius of Control Zone.—It is obvious that, in order to achieve the control accuracies previously mentioned, the control region must extend considerably beyond the entry gate to the final approach. It seems reasonable to require that the guidance system must have ±250-ft. positional information out to a radius of 30 miles because of the following considerations:

(1) It takes flying time (and therefore distance) to compute the flight tracks, ground speeds, and schedules necessary to bring the aircraft through the entry gate at the spacing necessary for safe operation and yet close enough to achieve the assumed landing rate; it takes additional time to perform the necessary control functions, such as changing altitude, changing speed, etc., to make good the computed schedules.

(2) Accurate knowledge of position is the prime requisite for performing these scheduling and control processes.

From the foregoing it appears that positional accuracy of the coordinate system employed for guidance and control directly affects the amount of traffic that can be moved safely and expeditiously in the terminal area.

Application of Parameters to R-θ System

In the United States, the *R-θ* system of traffic control has been agreed upon. *R-θ* systems have many advantages. They present relatively simple problems of siting and of air and ground computer design, and they permit tracks in any direction through the polar coordinate diagram. They require the measurement of two parameters, distance and angle (or azimuth). The measurement of distance to satisfactory operational

* If the additive tolerances of two aircraft become equal to the desired spacing (safety factor of 1 to 1), a collision can result. If the additive tolerances are made small in comparison with the desired spacing (large safety factor), safe operation is assured.

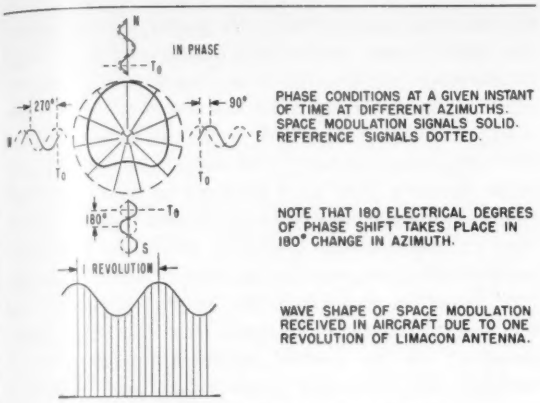


FIG. 5. Single Limacon antenna pattern.

accuracies (±250 ft.) has been achieved by several methods. The lack of accuracy in the measurement of angle or azimuth, on the other hand, has been one of the main difficulties in the use of such a system. For instance, in order to achieve ±250-ft. positional accuracy at 30 miles, the azimuth must be measured to approximately ±0.1° (from the $2R$ relationship).

The remainder of the paper will discuss an azimuth measuring technique with which accuracies in the order of ±1/2° have already been demonstrated and which appears to be capable of extension to give still higher degrees of accuracy.*

METHOD OF OBTAINING HIGH-ACCURACY AZIMUTH MEASUREMENT

In order to achieve high-accuracy measurement of azimuth suitable for aircraft guidance use in the terminal area, the principle of the single rotating limacon pattern[3] now used in the present V.O.R. has been extended. The objective of the present development is to secure an improvement of at least one order of magnitude in accuracy and at the same time to provide continuous information satisfactory for use both for visual presentation and with automatic equipment.

Let us first study the basic rotating single limacon system. Here, an antenna having a heart-shaped radiation pattern, as shown in Fig. 5, is rotated so that its field strength at any point in space varies as a sine wave with respect to time. Since the sine wave is produced by a rotating antenna pattern, its phase varies with the azimuth angle around the range station. In order to measure the azimuth position of the aircraft, a reference sine wave having constant phase in all directions is transmitted in all directions. The aircraft equipment then is made to compare the phase of the antenna rotational signal to that of the reference signal. The phase angle thus determined represents the azimuth position of the aircraft with respect to the ground station, since there is a one-to-one relation between electrical phase angle and azimuth angle. There are, however, certain limitations within the aircraft and ground equipment which affect the accuracy of phase angle measurement.

If some method of producing a greater phase shift per degree of azimuth shift can be employed, the accuracy of the azimuth measurement can be improved. An antenna with a pattern having eleven lobes, as shown in Fig. 6, will produce 11 cycles of a sine wave at any point in space for one complete rotation. The phase shift for a given change in azimuth angle is now eleven times as great as for a single limacon pattern, a 180° phase shift being produced in approximately 16° instead of in 180° of change in azimuth. The accuracy of the azimuth angle measurement is therefore increased by a factor of 11. However, there are eleven points of ambiguity in the measurement, since the individual cycles are not separately recognizable.

The ambiguity can be removed and the accuracy maintained by superimposing the eleven-lobe pattern on the single limacon pattern to give a complex space modulation as shown in Fig. 7. Now, by adding a second, higher frequency reference signal with which to compare the multilobe rotational signal, a "coarse" and "fine" combination is made available for a more exact unambiguous measurement of azimuth angle.

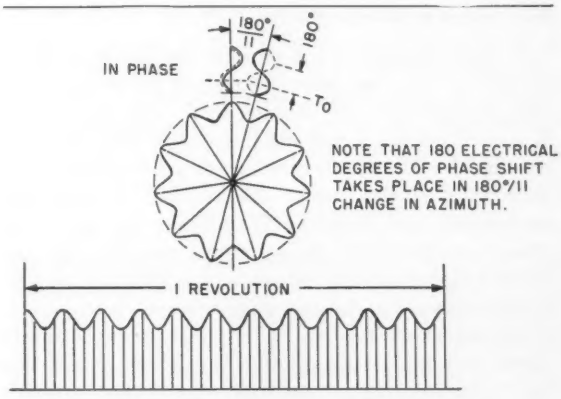


FIG. 6. Multilobe antenna pattern.

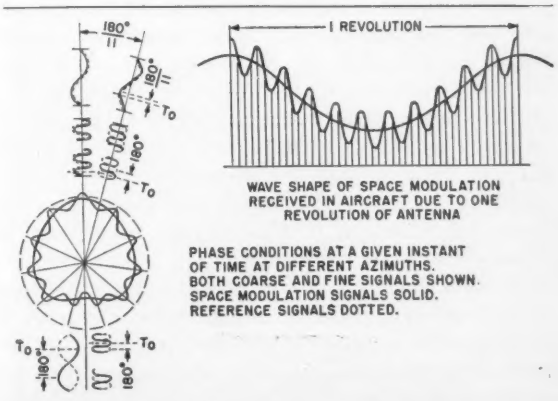

180°/11
180°/11
180°
T_0
T_0
T_0
T_0
180°
180°
1 REVOLUTION
WAVE SHAPE OF SPACE MODULATION RECEIVED IN AIRCRAFT DUE TO ONE REVOLUTION OF ANTENNA
PHASE CONDITIONS AT A GIVEN INSTANT OF TIME AT DIFFERENT AZIMUTHS. BOTH COARSE AND FINE SIGNALS SHOWN. SPACE MODULATION SIGNALS SOLID. REFERENCE SIGNALS DOTTED.

FIG. 7. Complex antenna pattern.

* It is known that, at the microwave frequencies used in this system, propagation anomalies can cause some error in azimuth measurement. However, at the present time, these errors are of inappreciable magnitude compared to equipment errors.[2]

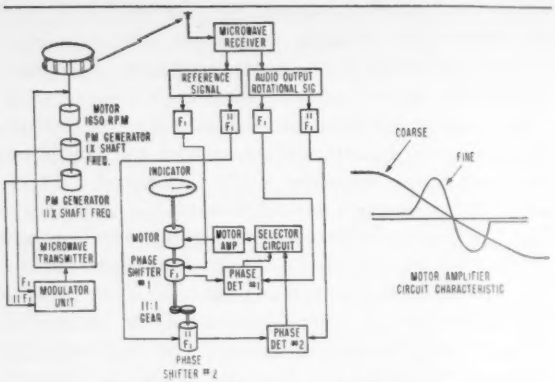


FIG. 8. Precision omni-azimuth system.

It might be well, at this point, to insert some numbers in this description. Suppose, for instance, that the antenna is rotated at 1,650 r.p.m. The sine wave due to the rotating single limacon pattern (coarse azimuth signal) will have a frequency of 27.5 cycles per sec. at any point in space. The sine wave due to the rotating multilobe pattern (fine azimuth signal) will be 302.5 cycles per sec. The coarse and fine reference signals therefore have to be 27.5 and 302.5 cycles per sec., respectively, so that the rotational or azimuth signals may be compared with them in phase.

Description of Decade System

A block diagram of the azimuth equipment is shown in Fig. 8. The two reference signals are produced by two generators on the antenna shaft, one generating a 27.5 cycle per sec. signal and the other a 302.5 cycle per sec. signal. These reference signals are impressed on a microwave carrier by a combination of frequency modulation and subcarrier techniques so that their phase is unaffected by the amplitude variations because of the rotating antenna pattern and so that they may be separated easily in the aircraft receiver.

The signal received by the aircraft at any azimuth therefore contains the complex amplitude modulation due to the rotating antenna pattern and the frequency modulation from the two reference signals. The four signals are separated in the aircraft receiver, the two rotational signals being fed directly to two phase detectors and the two reference signals being fed through two phase shifters to the phase detectors. With two signals of the same frequency impressed on it, the output of a phase detector is a d.c. voltage having amplitude and polarity dependent upon the relative phase between the rotational and reference signals. In this decade system, two phase detectors are used more or less in parallel. The output of one of them is applied to a motor geared to the two phase shifters. A phase shifter, as its name implies, shifts the phase of the signal being passed through it in direct proportion to the relative angular position between its rotor and stator. The motor drives the phase shifters so that the phases of the reference signals are shifted until they match the phase of the rotational signals, thus reducing the outputs of the phase detectors to zero. By gearing an indicator to the motor-phase shifter shaft, the electrical phase measurement is converted to an azimuth angle measurement. The motor amplifier has a selector circuit preceding it to determine which of the two phase detectors will control the motor. The output of the "coarse" phase detector (No. 1) is designed to have somewhat greater amplitude for a given phase shift than that of the "fine" phase detector (No. 2). However, it requires considerable change in the azimuth position of the aircraft before the signal from the "coarse" phase detector becomes greater than the signal from the "fine" phase detector. As the "coarse" output approaches zero, it becomes sufficiently low to allow the "fine" output to override it and take control. A relay is positioned so that the motor amplifier is controlled from either the "coarse" or the "fine" signal, depending on which is larger.

In normal operation, when the indicator is first turned on, assuming that the indication is not correct, the "coarse" signal controls the motor and positions the indicator approximately. As the motor drives the "coarse" phase shifter to give zero output from its phase detector, the "fine" signal becomes relatively larger, the relay switches over, and the motor is controlled by the "fine" signal. Essentially, therefore, the indicator is positioned by the "fine" signal, the "coarse" signal being used only to prevent ambiguities.

The Antenna Feed

The heart of the system is the antenna that has the complex azimuthal distribution previously described. A picture of the antenna (Fig. 9) show some of the details of its construction. Basically, the antenna consists of a triple-dipole element that produces a limacon radiation pattern within the confines of an omnidirectional waveguide section. This waveguide section consists of two 10-in. diameter circular plates separated in

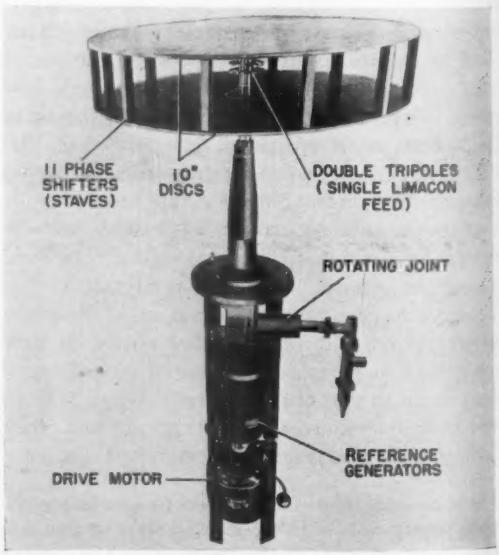


FIG. 9. Rotating element.

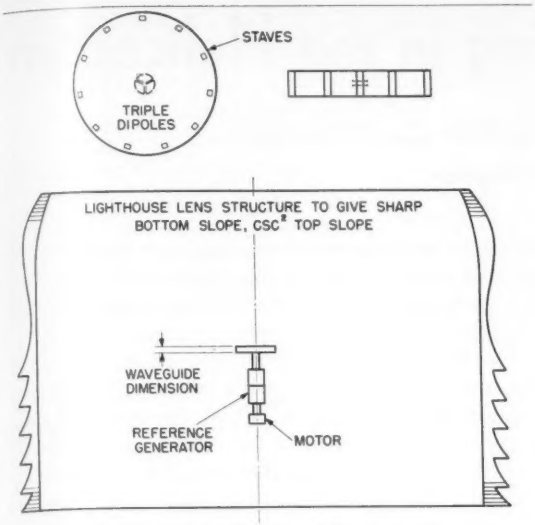


FIG. 10. Ground transmitting antenna.

accordance with the critical dimension of waveguide using the simple mode at this frequency. Near the circumference of the two metal discs are eleven equally spaced dielectric radio-frequency phase shifters (referred to as "staves") which give the multilobe pattern. The whole assembly has the appearance of a squirrel cage. The depth and spacing of the scallops in the pattern are controlled by the dimensioning and spacing of the staves. This antenna is rotated at 1,650 r.p.m. to obtain the space modulation previously described.

The Lens

The spinning antenna just described has a broad distribution of emitted energy in the vertical plane. Therefore, if it is mounted at sufficient height above the ground so that it "overlooks" the surrounding terrain and buildings, an appreciable portion of the energy would be directed downward where it would strike the ground or buildings and would be reflected up to any aircraft using the system. Such aircraft would then receive a signal with two components, one directly from the antenna and the other reflected from the ground or from surrounding buildings. This has two deleterious effects, the first being that interference patterns are formed which radically change the amplitude of the received signal at any point in space and the second being that a signal that starts off in one direction can be reflected and be received by an aircraft at an entirely different azimuth. Thus, an aircraft west of the station may be receiving a north or a south signal as well as the correct west signal.

Any energy reflected from the ground or from surrounding buildings into the region where signals are being received by aircraft thus causes inaccuracies in the azimuth measurement which are difficult, if not impossible, to eliminate or to predict. It is therefore important to prevent any appreciable amount of energy from striking the ground or any other reflecting surface.

This is accomplished by properly shaping the distribution of energy in the vertical plane. In order to make proper shaping feasible, the system is operated at microwave frequencies, approximately 5,000 megacycles per sec., where the size of the spinning element can be made small and where the necessary vertical beam-shaping antenna structure can be kept to a practical size.

The effects of ground transmission and multiple reflections are overcome by placing the spinning element at the focal point of a cylindrical lighthouse lens, as shown in Fig. 10. The vertical distribution pattern of this lens has a sharp cutoff at its lower edge. Thus, little power is directed below the horizontal where it can strike the ground or any buildings. Reflection effects are almost completely eliminated at all angles greater than approximately $^1/_2°$ above the horizontal. This represents an altitude of about 1,000 ft. at the edges of the control zone. Thus, a signal free from reflection effects is ensured in the operating region. It is also desirable to supply signals at fairly large vertical angles for aircraft at higher altitudes near the station. The vertical distribution pattern, although it is steep on the bottom, is therefore made to flare on the top side to give a cosecant-squared distribution.

Present Status of Development

At the present time, under the sponsorship of the U.S. Air Force (All Weather Flying Division and Watson Laboratories), the high-accuracy omni-azimuth range described in this paper is being planned so that it may later be integrated into a complete air navigation system, and azimuth accuracies in the order of $\pm^1/_2°$ have been demonstrated. Fig. 11 shows the experimental ground installation at the Sperry Flight Research Center at MacArthur Field, L.I.

(*Continued on page 27*)

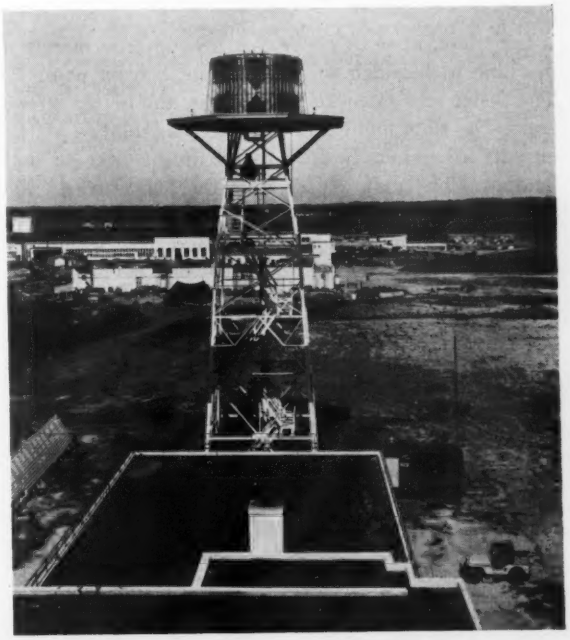


FIG. 11. Experimental ground installation.

Practical Instrument Flying in the Helicopter

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Bell Aircraft Corporation

An Approach to Helicopter Instrumentation

The history of the development of fixed-wing aircraft reveals that dependable and safe "round-the-clock" utilization was possible only after the acceptance of the "blind-flying" complement of instruments. An acceptable minimum group (gyro horizon, directional gyro, turn and bank, rate of climb, sensitive altimeter, and sensitive air speed) permitted night flying over terrain and water where visual reference is unpredictable because of unforeseen visibility restrictions, overcast, and lack of ground reference objects.

The parallel development of utilization of the helicopter has now reached a point where, in order to realize its full potential, it appears desirable to prove its capability of being safely flown by sole reference to blind-flying instruments for protracted periods of time.

Because of the unique flight characteristics of the helicopter—that is, the ability to fly slowly and to hover—the need for instruments has been minimized until the present. The line of reasoning seemed to follow the techniques applied to earthbound vehicles—that of slowly groping one's way at low altitudes through areas of restricted visibility. Flight regulations were passed following this idea. Weather minimums for helicopters were lenient, and so the dangerous narrow road of so-called "semi VFR" has been followed.

Let's look at it this way. A helicopter is merely a machine with which to get to point A from point B. The faster and safer we can do this, the better off we are. The slow flight and hovering capabilities of the aircraft are generally only useful during take-off and landing. The majority of time the helicopter is airborne it is in translation and can be treated as fixed wing. Let us fly it then as we would fixed wing—get up where we are clear of obstacles, and, if visibility or lack of ground reference preclude visual flight, then we will fly instruments.

Actually, the study of helicopter instrument flight can be divided into two general classes or speed ranges. Class one will arbitrarily have a limiting minimum flight air speed of 40 m.p.h. In it will fall such types of flight as military ship to shore, rescue, hospital, and liaison, and commercially such jobs as around-the-clock mail delivery and cargo and passenger haulage, such flights having acceptable weather conditions for visual reference at terminus with poor conditions existing in between. Class two will cover the range from 0 to 40 m.p.h. and will have specialized uses, probably necessitating specialized instrumentation.

The study of the problems involved in both phases has been under way for several years by both military and commercial groups, but to our knowledge no satisfactory solution to the *entire* problem is available at the present time. It appears that perhaps we've been approaching the problem the hard way—that is, we are trying to hover and fly slowly by instruments before we attempt to fly at moderate to higher speed where the helicopter begins to feel and fly like an airplane. If we can demonstrate that from 40 m.p.h. to $V_{max.}$ a helicopter can be satisfactorily and safely flown by sole reference to standard instruments, it seems reasonable to assume that fixed-wing instrument flight services, facilities, and regulations could be applied to the helicopter, thus greatly increasing its utility during marginal weather conditions. There are several reasons for selecting 40 m.p.h. as the lower limit.

(1) In fixed-wing practice, procedure and technique for climbs and let-downs are governed by the best climb or best descent air speed for the aircraft involved. Since the best climb air speed of most modern helicopters falls between 45 and 55 m.p.h., a minimum air speed slightly below this was chosen.

(2) If certification plans for helicopters materialize, safe flight below minimum certificated air speed will have to be demonstrated. The absolute minimum air speed controllable by reference to conventional instruments is questionable but appears to be in the vicinity of 30 m.p.h.

(3) Attitude gyro instrument indications are sometimes ambiguous at the slower air speeds because of erratic changes in rotor and fuselage pitch during transition from level flight to climb or descent. This phenomenon is dependent on fuselage shape and type of rotor and varies greatly from one make of machine to another. The effect is exaggerated at slower speeds.

The cruising speed of most modern helicopters falls fairly close to that of most light aircraft that have been filing instrument flight plans for years. Perhaps licenses could be granted to such a helicopter, restricting it to our arbitrary class one instrument flight. With the birth, development, and acceptance of suitable instrumentation for hovering flight, a second class of license might be applied to the helicopter in which these instruments were installed, enabling it to utilize various flight facilities in a manner more adaptable or suitable to slower flight. Such licensing plans do not appear too unsound at the present time.

Presented at the Rotating Wing Aircraft Session, Eighteenth Annual Meeting, I.A.S., New York, January 23–26, 1950.

* Experimental Test Pilot.
† Chief Test Pilot.

The immediate question is, of course, can a helicopter qualify for our hypothetical class one?

In general, the flight characteristics of most helicopters are conventional at speeds above 40 m.p.h. If the cyclic control stick is moved forward, the nose will drop and the helicopter will stabilize at a new higher air speed proportional to stick position. If power is not added, the aircraft will lose altitude, as will a fixed-wing aircraft. Turns are coordinated with lateral cyclic stick (ailerons) and rudder pedals. Headings can be maintained by rudder application, and air speed can be held to within a few miles per hour by longitudinal cyclic stick displacement.

The outstanding difference between rotary-wing and fixed-wing aircraft control characteristics at speed is one of stability.

Stability

The more stability an aircraft exhibits, the less fatiguing it is to fly on instruments. Since helicopters, in general, do not possess as much overall stability as fixed-wing aircraft, flight instruments must be more closely monitored. In discussing stability characteristics of aircraft two types are to be considered: the short period and the long period or phugoid.

In the fixed wing, short-period stability is influenced generally by fixed stabilizer damping and longitudinal mass inertia of the fuselage. In helicopters, although the analogy is not exactly correct, short-period stability is treated mainly as a rotor problem, with fuselage characteristics secondary in importance because of their delayed action. It is this response that gives the ship its feel. The type of rotor system used, the weight of the rotor, and whether or not any stabilizing device is incorporated are the factors influencing short-period response. Most rotor stabilities are divergent, and it is this response to gusts or small cyclic displacements which makes a helicopter acceptable or not for the precise corrections required in instrument flying. Through experience, a pilot could learn to fly a helicopter whose rotor exhibited severely divergent response, but the concentration required would be extremely fatiguing. N.A.C.A. is currently studying response rates of various types of helicopters and rotors, possibly with the object in mind of establishing a limit of acceptability of divergent response.

At higher speed, where the aerodynamic characteristics of the fuselage begin to modify rotor effects, the problem becomes one of phugoid. Much discussion has been centered about fixed-stick versus stick-free stability. In reality, the two are similar. During stick-fixed recovery from an oscillation, the fuselage, to which the stick is attached, is damped and righted by aerodynamic moments due to fuselage shape and fixed stabilizer setting. In a stick-free recovery, common to fixed-wing aircraft, the righting moments are gained by changing pressures on the control surfaces as a result of air-speed variation which move the surfaces to their trim positions. In so doing the fuselage is moved and righted. Some experimental rotary-wing machines have auxiliary airfoils linked to the cyclic control system to furnish righting forces. This is an example of stick-free stability. Others have centering springs or bungees to return mechanically the cyclic stick to a trim position. This results in a feel of stick-free stability but is, in reality, a form of fixed-stick stability. Long-period stability is equally as important as short-period response, for it greatly eases the pilot's job during protracted instrument flight. It does enable so-called "hands-off" flight while reading a map or using radio equipment.

At cruising speed, several present-day helicopters exhibit a fair degree of long-period longitudinal stability and appear acceptable for class one instrument flight.

Practical Flight Tests

In line with the foregoing, it was decided to inaugurate an instrument flight program that would have as its primary objective the determination of the instrumentation requirements needed for satisfactory instrument flight within the 40 m.p.h. to $V_{max.}$ air-speed range. A Model 47D was made available for this purpose. The entire inner surface of the Plexiglas bubble, including the cabin doors, was lined with amber acetate sheeting. This system of blind-flight simulation was chosen for several reasons: First, it provided the pilot with a completely black cabin when complimentary blue goggles were worn. This ruled out all possibility of outside reference. Necessary panel lighting was supplied for the pilot's use by small Grimes "Xmas tree" type lamps. Second, the visibility of the safety pilot was in no way impaired. This is considered a comparatively important factor when flights are to be conducted in areas of moderately heavy air traffic.

An auxiliary instrument panel was mounted in front of the left seat, adjacent to the regular panel, in a direct line with the pilot's vision (Fig. 1). We attempted to locate the instruments on the auxiliary panel so that a minimum amount of rearranging would be required on

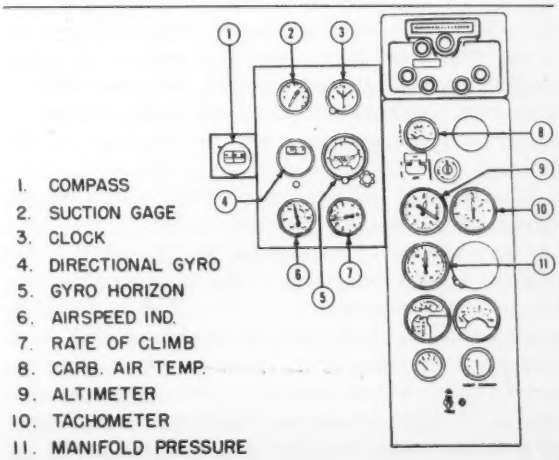

Fig. 1.

the regular panel. The compass was positioned along the extreme left edge of the auxiliary panel. The airspeed indicator was also moved to the auxiliary panel. Two other instruments, the tachometer and the altimeter, were repositioned, and the following additional instruments were installed: (1) suction gage, (2) clock, (3) directional gyro, (4) gyro horizon, and (5) rate of climb.

All gyro instruments were of the vacuum-driven type. Vacuum-driven instruments were chosen because they were available and because facility for driving a vacuum pump existed.

Considerable delay in the final instrumentation did not permit preliminary flights to begin until the third week in December, 1949. We hoped to obtain as much information as possible within our limited budget. In line with this, our program called for as many pilots as possible to fly the aircraft for short periods of time. The majority of the flights were to be made with one man serving as safety pilot. It was hoped that he would be able to establish and correlate difficulties and/or proficiencies demonstrated by each of the various pilots. The safety pilot's impressions and the "first impressions" of the pilots could then be discussed in detail before any changes were made in the instrumentation, cockpit procedures, etc.

A total of seven pilots flew the machine for an average of 35 min. each. The individual instrument proficiencies of the pilots involved varied considerably. This one factor, although it affected the pilot's ability to relax or his ability to make corrections rapidly, did not affect certain fundamental difficulties that all pilots appeared to exhibit. The safety pilot observed several fundamental difficulties:

(1) Although the pilot was attempting to hold straight and level flight, he would repeatedly allow the machine to roll slowly to the right. He would first notice this change from a stable flight condition on the directional gyro a second or two after the turn had commenced. His attention would then be divided between the two gyro instruments for necessary correction. Pilots' comments on this difficulty were interesting. In the majority of the cases, all pilots felt that the rolling difficulty was not one of roll but one of directional instability—that is to say, in flying the machine it was felt that repeated directional corrections were required and that all roll errors detected on the gyro horizon were the result, not the cause, of the difficulty.

The Model 47 helicopter is provided with a bungee spring in the lateral cyclic control system. This spring has been selected to compromise lateral control forces inherent in the rotor system, so that at no time does the force exceed approximately $1^1/_2$ lbs. Within the range of air speeds flown on this test, the lateral stick force averaged approximately $^1/_2$ lb. to the *right*. Another factor that should be considered when discussing this "roll to the right" tendency is the roll rate versus lateral stick displacement characteristics of the machine. To the best of our knowledge, all single-rotor helicopters in forward flight demonstrate a higher rate of roll in one direction than in the other for a given amount of stick displacement either side of neutral. This phenomenon is dependent upon the direction of rotation of the main rotor. In the Model 47, assuming that all directional indications were eliminated and assuming that the pilot were to make a series of equal lateral corrections either side of neutral, a banked turn to the right would evolve.

(2) A tendency existed for all pilots to lead their air speed too much when changing to a new air speed. For example, in changing air speed from, say, 40 to 70 m.p.h., the pilot would invariably lower the nose or change attitude more than necessary. He would then observe a rate of acceleration on the air speed indicator which was known to be higher than desired. An attitude change would then be accomplished which would result in the air speed all but stabilizing at 60 or 65, and then, by small corrections, the desired 70 m.p.h. would be reached. Attempts to decrease air speed would also result in the same type of overcontrolling. The difficulty experienced when air-speed changes were made was fortunately on the safe side and can be explained by the comparatively high pitching rates associated with longitudinal stick displacements. The pitching rates, in general, were higher than anticipated by the pilot. Training and practice would enable a pilot to obtain the necessary pitching rate information from the attitude gyro and would, in turn, reduce or eliminate his overcontrolling tendencies. As inferred by our previous discussion on stability, the trend toward overcontrolling increases at lower air speeds. The gyro horizon in its present state may then prove completely unsatisfactory as an indication device for stable flight in this speed range. This possibility and a suggested approach to the problem are discussed in detail later in the paper.

(3) A tendency also existed for the pilots to anticipate inaccurately the proper amount of lead required to roll out of a turn on a new heading—that is to say, the pilot would lead his recovery roll-out by approximately 10°, only to find that he was overshooting his desired heading objectionably.

Since no turn-and-bank indicator or clock was installed, all pilots would establish a turn by holding a bank angle of from 15° to 20° on the gyro horizon. This bank angle, while approximately correct for a standard 3° per sec. rate turn in the average airplane, was far greater than necessary in the helicopter—hence, the tendency to overshoot. While it may later be found desirable to establish a higher rate turn as standard for the helicopter, it was decided, after discussion, to use the 3° per sec. rate, since all pilots are familiar with it and its use in making timed turns. A bank angle of 8° to 10° is sufficient for this rate at normal helicopter cruising speeds.

Since all pilots had difficulty in maintaining a level flight attitude or zero bank angle, it was concluded that a larger airplane reference in the gyro horizon

instrument would enable the pilot to detect more readily small discrepancies.

Perhaps the most important single revelation in this first phase of the flight program was the percentage allocation of time to various instruments and how it differed from the time normally spent on the same instruments when flying fixed wing. Considerably more time had to be spent monitoring the air speed and directional gyro than would normally be needed in an airplane. This directly pointed the way toward optimum instrument location on the panel. On the basis of the discussion that followed the preliminary flights, a new instrument panel was laid out (Fig. 2).

As you can see, considerable rearrangement took place. An attempt was made to put the most used instrument in the best location on the panel and to locate the instruments so that they could be used in pairs or in partial groups in the event of malfunctioning or failure of a power source or instrument. Although a vacuum-type turn-and-bank indicator was installed, it is recommended that this instrument be of the electrically driven type. This would still provide the pilot with necessary information to continue flight should the vacuum source fail. Only a limited amount of flying—15 to 20 hours—has been spent with the new panel arrangement. However, all the pilots that have flown the machine have commented favorably on the versatility of the panel. It is interesting to note that a fairly recent British paper points out the psychological advantages of locating the two most used instruments—the directional gyro and the gyro horizon—along a common vertical, rather than horizontal, axis. Although it would be interesting academically to try such an arrangement, it is believed that all pilots, at least in the United States, who have instrument experience would have less difficulty and are more familiar with the side-by-side arrangement.

Proper placement of the manifold pressure gage and the tachometer was also stressed. Many feel that, in the case of a helicopter, the tachometer has the same importance as that normally given to the air speed in a fixed-wing aircraft. The use of the manifold pressure gage as a means of establishing power setting for climbs and descents is well known. Some may comment on the separation of these two instruments by the turn-and-bank indicator. No one reported any disadvantages in doing this, and everyone felt that the needle and ball should command a center position.

All normal instrument flight maneuvers plus many unusual attitude recoveries were practiced without any difficulty. This was true even on partial panel with the gyro instruments caged. An interesting thing to note is that no one had any difficulty with the roll to the right tendency after it had been discussed.

The 40 m.p.h. minimum air speed worked out extremely well. Occasionally, a pilot would allow his air speed to drop to 30, but there was need for little concern and the pilot could, without difficulty, reestablish his minimum. In contrast with this, in the fixed wing the air speed is inadvertently allowed to drop below stalling speed.

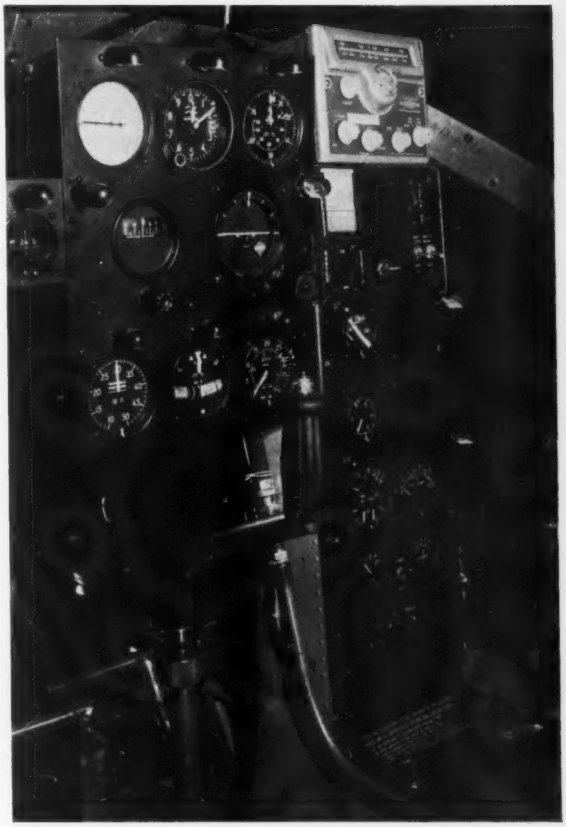

FIG. 2.

All in all, we have, at least to *our* satisfaction, demonstrated that so-called class one instrument flight is possible, is a reality, and is practical. Improvements can and will be made to present instruments and to helicopter stability which will make such flight even more practical. Step one has been taken.

THE LOW-SPEED PROBLEM

With practical instrument flight a reality at higher speeds, what has been done or what can we do about slower speed flight with emphasis on the 0 to 15 m.p.h. range? Frankly, we haven't had much luck. With standard instruments, we've been able to hover for short periods of time, but the feeling exists that there isn't enough information being furnished the pilot for accurate control. We've made jump take-offs with conventional instruments, but we might as well close our eyes for the first 30 sec. The information just isn't there, and control motions are purely mechanical through experience.

We have come up with some ideas and requirements for instrumentation, however. Three important points to consider are:

(1) There is a definite need for more accurate velocity information at slow speeds. The common pitot static air-speed system becomes completely unreliable

for several reasons. First, rotor downwash during slow flight definitely affects accuracy by creating turbulence in the vicinity of pressure and static orifices. Second, the dynamic air pressure is of such a low value as to be unuseable for instrumentation purposes (20 m.p.h. equals 0.197 in. H_2O; 10 m.p.h. equals 0.049 in. H_2O). The effects of gusts on air-speed indication is another problem to be considered. A gust of 20 m.p.h. under average wind velocity is not uncommon. What technique does the pilot use then when he is flying at an air speed of 10 m.p.h. and is confronted with a gust of moderate duration of 20 m.p.h.? Does he follow the air-speed indicator, which reads 30 m.p.h.? Probably not—he attempts to average it out. To be truthful, he ignores the air speed momentarily. He holds the helicopter in the same state or attitude. He does this because in most helicopters there is a definite relationship between attitude and stabilized velocity. There may be no acceptable way to measure low air speeds directly, but the door is certainly open for development along the attitude concept.

(2) The problem of yaw in a helicopter, especially at slow speeds, is an acute one. At higher speeds, where directional stability is greater because of fuselage streamlining, deviation from relative wind is slight, and an air-speed device may be fixed and aligned with the longitudinal axis. For this reason the problem of yaw effects on air speed has been inconsequential in fixed-wing practice. Since in the lower speed ranges, the helicopter, by virtue of its unique characteristics, may fly sideways or even backwards, the side component of wind velocity may be greater than the forward component. Even though the longitudinal axis may be aligned with desired heading, side drift may distort the air path considerably. The need for some indication to the pilot of yaw angle, either in the form of a separate instrument or tied with the lubber line on the directional gyro or compass, is apparent.

(3) There should be some means of predicting the trend of helicopter attitude. If the sense of anticipation is not obtainable, at least an instantaneous knowledge of deviation from steady state should be made available. Because the rotor is universally mounted on the mast, it may freely change position because of gusts or cyclic pitch excitation and is followed by fuselage attitude change and/or translation. Fuselage-based gyro instruments suffer from this delay. The delay in fuselage movement also wreaks havoc with beginners attempting to hover a helicopter visually. When hovering visually, the pilot, through experience, mentally integrates fuselage displacement and pitching rate to make appropriate control corrections. A high rate of change of attitude and small fuselage displacement may require the same control correction as a slow rate and greater displacement to bring the aircraft back to the desired attitude. Because the magnitudes of both factors can be readily observed during visual flight, this problem is easily conquered. When flying instruments the anticipatory problem is even greater.

The limited intelligence offered the pilot by present-day gyro instruments precludes satisfactory hovering flight. Displacement can be read with some degree of accuracy on the face of gyro attitude instruments, but presentation of rate is poor. Enlarging the instrument face might help, but the real solution seems to lie in an instrument of the Zero Reader type—one in which rate and displacement are integrated in the final indication.

We have discussed a few of the problems; there are many others, of course, but these are the fundamental ones. The more specialized a job the helicopter must do, the more specialized the instruments become. Closer cooperation and mutual understanding is necessary between the designers of instruments and the helicopter industry for the final solution.

Procedures

Let us assume that the proper instrument has been developed for hovering and slow-speed instrument flight. The problem then is how to modify present radio aids or to design new systems of instrument let-down for more optimum use by the helicopter. Contrary to popular belief, there seems to be little advantage in vertical let-down methods. In the first place, power required for vertical let-down is high. The danger of settling with power is ever present (a partial blade stall condition associated with helicopters) if rates of descent are not carefully controlled. The fixed-position vertical let-down over a marker seems also to offer severe problems from the electronic standpoint in presenting sufficient information to the pilot. The problem is not in locating the marker initially but in staying over it or in it during descent. Wind velocity is another factor working against zero or extremely low-speed let-downs. Picture a let-down at 20 m.p.h. indicated air speed if the wind velocity were unknown and were 30 m.p.h. The aircraft would then actually be drifting backwards with respect to the ground, an extremely undesirable condition. With fixed-wing aircraft, wind velocity and even directions are relatively unimportant because of the high speeds involved. Wind knowledge is essential for optimum let-down procedures. Here are two possible solutions:

(1) An omnidirectional radio device on which the helicopter may home can be utilized. The pilot could be notified of wind direction and velocity by the control tower, and all approaches would be made into the wind using some minimum air speed as a constant to which average wind would be added for let-down indicated air speed. For instance, if a particular airport, because of traffic or terrain, required a let-down path of 30 m.p.h. and 500 ft. per min. under no wind conditions and if the wind were 20 m.p.h., the let-down air speed would be 50 m.p.h. I.A.S. This would ensure more consistent let-down paths and enable shorter and steeper approaches for obstacle clearance (Fig. 3).

(2) A glide-path type of radio device could be developed to be oriented according to wind direction and velocity by the tower operator. In this type of system

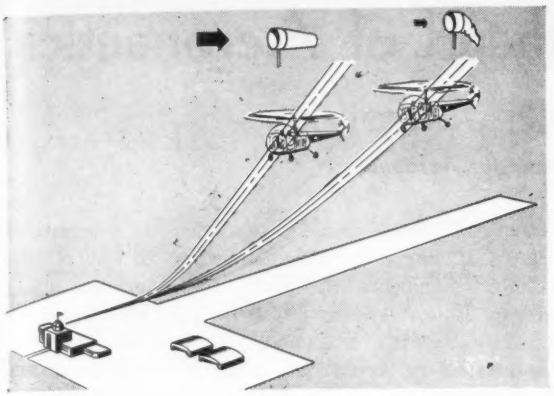

FIG. 3.

a fixed air speed would be flown consistent with desirable flight characteristics of the helicopter. The tower operator would vary the glide-path angle according to average wind velocity at the time of let-down. In high winds the glide path would be set at a rather steep angle, say possibly 60°. The desired path for calm air would limit the lowest angle to which the path would be adjusted, and the adjustment angles in between would vary according to local wind velocity. Under any condition, however, the path angle would be much steeper and would require less space than present instrument landing paths because of the approach speeds involved.

Variations of landing systems are too numerous to discuss in this paper and present a complete study in themselves; however, there are certain criteria to be considered in the planning of procedures or design of equipment.

(1) Because of the slower speeds of the helicopter, the area covered and the time involved for let-down can be minimized. Approaches will generally be steeper.

(2) Wind velocity and direction are extremely important in the design of equipment and the setup of procedures for optimum performance. The slower the approach speed, the more important wind direction becomes.

(3) Since no runways are required for the helicopter and approaches nearly always must be made directly into the wind, landing equipment can be portable and should be readily adjustable in azimuth and possibly pitch. The characteristics of high-frequency radio equipment lend themselves admirably to the design problem. During emergencies, such equipment could be mounted on a truck and moved to any level cleared area.

We have outlined the problem; if we can conquer "Old Man Weather," the field of helicopter operation will be widened immeasurably. The armed forces especially will benefit. It will take planning and coordination from all groups—from those who develop and from those who give us the right to use such development through legislation and control. The present state of technological skill should bring the solution to us faster than it did to fixed wing, and we can certainly profit by their experience. The Air Forces, the Navy, the Marines, and some commercial groups that we have talked with have ideas on the fire, and you can bet your bottom dollar we at Bell have too. We're trying them soon. The answer might be just around the corner.

A Precision Omnidirectional Radio Range for the Terminal Area

(*Continued from page 21*)

SUMMARY AND CONCLUSION

It has been shown how the accuracy requirements of radio aids used for guidance in the terminal region determine the maximum capacity of this area. Of the several elements of a polar-coordinate system, the azimuth element is the more difficult to develop.

This paper has reported upon a technique capable of improving azimuth accuracy sufficiently to meet anticipated requirements. The purpose behind the presentation has been to: (1) secure criticism leading toward a better definition of operational requirements, and (2) indicate a trend in the development of new radio aids to air navigation which may affect operational planning.

It is concluded that: (1) the maximum capacity of an air traffic control system is based on the absolute positional accuracy of the guidance system, and (2) in an omni-DME or *R-θ* system such as has been discussed in this paper, the accuracy of the azimuthal measuring system, because of the difficulty of obtaining sufficient accuracy, determines practically all of the other parameters of the whole guidance and control system.

REFERENCES

[1] Bowen, E. G., and Pearcey, T., *Delays in the Flow of Air Traffic*, Journal of the Royal Aeronautical Society, Vol. 52, p. 251, 1948.

[2] Crawford, A. B., and Sharpless, W. M., *Further Observations of the Angle of Arrival of Microwaves*, Proc. I.R.E., November, 1946.

[3] Luck, D. C. G., *A New Method for Radio Guidance of Aircraft*, A.I.E.E. Technical Paper No. 41–93, March, 1941.

Standardizing the Shorthand of Aeronautics

HUGH L. DRYDEN* and JAMES A. HOOTMAN†

National Advisory Committee for Aeronautics

A PROJECT OF CONSIDERABLE INTEREST to aeronautical engineers and technicians was recently completed by the American Standards Association with the final approval and release to the public of a new standard, *Letter Symbols for Aeronautical Sciences*. The publication of this standard is a significant indication of the unity that may be achieved in a complex field of applied science in arriving at a common method of "shorthand" notation which employs a system of symbols understandable to all who have occasion to consult the literature of the field.

American industry and technology owe a debt of gratitude to the American Standards Association for its untiring work in fostering the development and use of standards in the various fields of pure and applied science and engineering and by producer and consumer groups. The American Standards Association is a federation of 100 trade associations, technical societies, and consumer organizations. It has been responsible for the formulation of more than 1,100 American Standards. These standards represent, in each case, general agreement on the part of manufacturer, distributor, and consumer groups as to the best current industrial practice with regard to some specific problem. An American Standard implies a consensus of those substantially concerned with its scope and provisions. The work of the Association is carried out with the help of many committees and subcommittees of specialists who are carefully selected because of their background of experience and because, as a group, they constitute a representative cross section of the scientific and technical workers in the field involved. Manufacturers, consumers, technical societies, and Governmental agencies are represented on the committees and subcommittees that set up these standards. Hundreds of groups throughout the country are taking part in the work, and the completed standards are used widely by industry and by municipal, state, and Federal governments. The American Standard, *Letter Symbols for Aeronautical Sciences*, American Standards Association publication No. Z10.7-1950 is the work of Subcommittee No. 7, one of twelve subcommittees operating under Sectional Committee Z10 on Letter Symbols and Abbreviations for use in Science and Engineering. Other subcommittees cover mathematics, hydraulics, mechanics of solid bodies, structural analysis, heat and thermodynamics, photometry, electrical and magnetic quantities, radio, physics, chemical engineering, and abbreviations. The work of Subcommittee No. 7 was sponsored by the American Society of Civil Engineers, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, the American Society for Engineering Education, and the American Association for the Advancement of Science. The National Advisory Committee for Aeronautics and the Institute of the Aeronautical Sciences acted as collaborators. The membership of the Subcommittee included representatives of a number of leading universities, aircraft manufacturers, and government agencies, as well as outstanding aeronautical consultants.

The Standards released by the American Standards Association are intended as guides to aid the manufacturer, the consumer, and the general public. The Association states, as a part of its general policy, that the existence of an American Standard does not in any respect preclude any party who has approved of the Standard from manufacturing, selling, or using products, processes, or procedures not conforming to the standard. This general policy as applied to the American Standard *Letter Symbols for Aeronautical Sciences* may be interpreted to mean that this standard is to be used as a guide whenever practicable but that it is entirely permissible for any member of an organization that has approved the standard to deviate from the recommended symbol usage when good and sufficient reason exists for so doing.

Certain basic principles are applicable in all letter-symbol standardization. Letter symbols should not be confused with abbreviations, mathematical signs and operators, graphical symbols, or chemical symbols. A letter symbol is a single character, with subscript or superscript if required, used to designate a physical magnitude in mathematical equations and expressions. Two or more symbols written together represent a product. It is this stipulation that makes unsuitable the use of more than one letter in representing any primary concept and gives rise to the only serious conflicts between the recently approved American Standard and common practice in the past in the aeronautical field. A given symbol should always be used for the same physical magnitude regardless of the units employed and of special values occurring for different states, points, parts, times, etc. Units or special values may be designated by subscripts, superscripts, or upper- and lower-case letters when both are specifically included as symbols in a standard list. Subscripts are commonly used to indicate constancy of a particular physical magnitude, such as pressure or temperature, when there are other variables. A subscript preferably should be a simple character, although it is not mandatory that it be a single letter, as is the case with sym-

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American Standard

Letter Symbols for Aeronautical Sciences

A symbol indicated as an alternate is not preferred. Symbols having equal rank are not qualified as alternates.

The dimensions given in the third column and the definitions given in the fifth column are merely illustrative and form no part of the present standard. With regard to the indicated dimensions, and in a particular system of units, M represents Mass, L represents Length, T represents Time, and θ represents Temperature.

Letter Symbols for Primary Concepts

Symbol	Concept	Dimensions	Also Appears in Z10 Publication	Remarks
a (lc)	Slope of lift curve	Dimensionless	———	$a = \frac{dC_L}{d\alpha}$
a (lc)	Velocity of sound	LT^{-1}	———	Use *c* (lc) for alternate
A (cap)	Area, cross-sectional	L^2	Z10.2, Z10.4, Z10.6, Z10.8, Z10.12	Use *S* (cap) for surface or projected area
A (cap)	Aspect ratio	Dimensionless	———	See $\mathcal{A}$R (cap, written together) for alternate
$\mathcal{A}$R (cap, written together)	Aspect ratio, alternate for	Dimensionless	———	———
b (lc)	Span	L	———	Used in Z10.3, Z10.6, Z10.8 for breadth
b (lc)	Blade width (propellers)	L	———	———
c (lc)	Chord, of an airfoil	L	———	———
c (lc)	Velocity of sound, alternate for	LT^{-1}	Z10.6, Z10.12	———
c (lc)	Coefficient, alternate for; section coefficient	Dimensionless	———	———
c_p (lc)	Specific heat, at constant pressure	$L^2T^{-2}\theta^{-1}$	Z10.4, Z10.6, Z10.12	———
c_v (lc)	Specific heat, at constant volume	$L^2T^{-2}\theta^{-1}$	Z10.4, Z10.6, Z10.12	———
C (cap)	Coefficient	Dimensionless	Z10.2	See *K* (cap) for factor which may have dimensions; see page 19 for usages
C (cap)	Concentration	Dimensionless	Z10.4	———
d (lc)	Diameter	L	Z10.3, Z10.4	Interchangeable, but conflicts with differential operators shall be avoided
D (cap)	Diameter	L	Z10.2, Z10.3, Z10.4, Z10.6, Z10.8, Z10.12	Interchangeable, but conflicts with differential operators shall be avoided
D (cap)	Drag	MLT^{-2}	———	———
e (lc)	Span effectiveness	Dimensionless	———	———
E (cap)	Energy	ML^2T^{-2}	Z10.2, Z10.3, Z10.6, Z10.8, Z10.12	———
E (cap)	Modulus of elasticity; Young's modulus	$ML^{-1}T^{-2}$	Z10.3, Z10.6, Z10.8	———
f (lc)	Frequency	T^{-1}	Z10.3, Z10.6, Z10.8	———
F (cap)	Force	MLT^{-2}	Z10.2, Z10.3, Z10.4, Z10.6, Z10.8, Z10.12	See page 19 for usages
F (cap)	Thrust; stream thrust (combustion)	MLT^{-2}	———	Use *T* (cap) for propeller thrust
g (lc)	Acceleration due to gravity	LT^{-2}	Z10.2, Z10.3, Z10.4, Z10.6, Z10.8, Z10.12	———
G (cap)	Mass velocity; mass-flow, per unit cross-sectional area, per unit time	$ML^{-2}T^{-1}$	Z10.4, Z10.12	———
G (cap)	Shear modulus	$ML^{-1}T^{-2}$	Z10.8	———

Fig. 1. Sample page.

bols for principal concepts, several of which may be combined as factors of a product in a mathematical expression. A multiple subscript, sometimes divided by a comma, refers to more than one state, point, part, time, etc.

It is inevitable that a single letter symbol must frequently represent several different physical magnitudes, inasmuch as the total of the upper- and lower-case letters in the English and Greek alphabets is not sufficient to represent all of the physical magnitudes occurring in a given field of a physical science. Such difficulties may be resolved in one of several ways: by using the given symbol with a special subscript or superscript selected by the author; by the use of an alternate symbol in a standard list, if alternates are available; or by a slight change in the name of the magnitude. The principles mentioned herein, which are discussed at greater length in A.S.A. publication Z10.7-1950, should be carefully observed by authors in preparing manuscripts, and the many numbers, letters, and signs that are similar in appearance should be distinguished carefully. It is preferable that authors employing a considerable number of symbols include in their papers a symbol list in which all of the symbols used are defined. If a table of symbols is not included in the manuscript, reference should be made to the standard lists from which the symbols are taken.

The American Standard Z10.7-1950, *Letter Symbols for Aeronautical Sciences*, is available in booklet form from the American Standards Association, Inc., 70 East 45th Street, New York 17, N.Y. The publication contains two main divisions, "Letter Symbols for Primary Concepts" (see Fig. 1 for sample page) and "Letter Symbols for Secondary Concepts." The second division is devoted to subscripts and superscripts. An appendix containing an alphabetical index by concepts is also included. Thus, two listings of the same symbols and quantities are provided to facilitate use of the standard, the first being alphabetical by symbol and the second being alphabetical by concept. Information is presented in the first list under five headings as follows: Symbol, Concept, Dimensions, Other Z10 Publications in which the Symbol Occurs, and Remarks. The symbol column and the concept column of this first listing constitute the American Standard, and all subsequent columns and listings are provided merely to facilitate use of the standard. Under the heading "Remarks" in the fifth column of the first listing, some definitions are included, but these definitions form no part of the standard.

A number of special letter symbols relating particularly to meteorology and to servomechanisms were considered by the subcommittee. It was concluded that letter symbols and concepts in these fields are so specialized as not properly to fall within the scope of Subcommittee No. 7. Accordingly, no attempt has been made to include in the present standard any letter symbols for special concepts in meteorology or servomechanisms.

It was recognized that a great majority of the papers and reports in the various fields of aeronautics are duplicated by some process relying upon the use of typewriters. Accordingly, no use has been made of type-face variations to distinguish letter symbols. It was felt that this feature would simplify the preparation of typewritten duplications; however, in the case of printed publications it is intended that letter symbols, letter subscripts, and letter superscripts, whether upper or lower case, be printed with italic type unless definitely specified otherwise.

It is generally permissible to use any of the recommended letter symbols for primary concepts as a subscript in application to another symbol for a primary concept. This follows logically from the fact that a given primary concept may be employed in some cases as a modifying or secondary concept. For this reason no attempt was made to include in the subscript list all of the symbols that may be employed as subscripts, particularly where such symbols may be found in published lists of principal letter symbols.

The National Advisory Committee for Aeronautics has from time to time compiled lists of those symbols generally recognized and widely used in the various fields of aeronautics. These lists were prepared and approved by certain of the N.A.C.A. subcommittees and for the most part have been given little circulation beyond the subcommittee membership and the Committee's own Laboratories, although one such symbol list entitled *Symbols for Combustion Research*, prepared by the N.A.C.A. Subcommittee on Combustion, was released in June, 1948, as N.A.C.A. Technical Note No. 1507. The various N.A.C.A. symbol lists have been useful in the past as guides to N.A.C.A. authors and probably to others who had access to them because of their affiliation with organizations represented on the various N.A.C.A. subcommittees. Their usefulness has been limited, however, because they were not available to the general public, and it was considered entirely appropriate for them to be utilized by the American Standards Association as important sources of information in the preparation of the present standard.

It has been mentioned that the present standard deviates in a few cases from what has been rather general practice in the aeronautical literature. The most significant of these deviations are inescapable, however, without violation of the basic principles of symbol notation, and the changes recommended appear amply justified. Thus, for example, it will be noted that no symbols for Cauchy Number, Euler Number, Froude Number, Grashof Number, Graetz Number, Nusselt Number, Peclet Number, and Prandtl Number appear in the table of "Letter Symbols for Primary Concepts." Instead, *N* (cap) appears as the symbol for Number in general. The symbols *Ca*, *Eu*, *Fr*, etc., appear in the table of subscripts. If it is desired to specify a particular number of special significance, such as Euler Number or Prandtl Number, the general principal symbol *N* (cap) is written with the appropriate subscript *Eu*

(*Continued on page 69*)

I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

Column Behavior in the Plastic Stress Range

By

John E. Duberg and Thomas W. Wilder, III

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This paper presents a summary of the significant findings of a theoretical study of column behavior in the plastic stress range. When the behavior of a straight column is regarded as the limiting behavior of an imperfect column as the initial out-of-straightness approaches zero, the departure from the straight configuration occurs at the Shanley tangent-modulus load. Without such a concept of the behavior of a straight column, one is led to the unrealistic conclusion that lateral deflection of the column can begin at any load between the tangent-modulus value and the Euler load, based on the original elastic modulus.

The behavior of a column with vanishing initial out-of-straightness at loads beyond the tangent-modulus load depends upon the stress-strain curve for the material. A family of load-lateral deflection curves is presented for idealized H-section columns of various lengths and of various materials that have a systematic variation of their stress-strain curves. These curves show that for columns whose material stress-strain curves depart gradually from the initial elastic slope, which is characteristic of stainless steels, the maximum column loads may be significantly above the tangent-modulus buckling load. If the departure from the elastic curve is more abrupt such as for the high-strength aluminum or magnesium alloys, the maximum load is only slightly above the tangent-modulus load.

The Solution of Aeroplastic Problems by Electronic Analogue Computation

By

Jonathan Winson

Fairchild Engine and Airplane Corporation

The ease with which complex physical problems are resolved by machine computation of the analog type has led to an inspection of flutter and related aeroelastic phenomena with a view toward automatic solution of these problems. It is found that automatic solution is feasible and can be carried out in the following manner: The basic aeroelastic equations for arbitrary wing motion are written and entered in a commercial electronic computer. The elastic, inertia, and aerodynamic properties of the physical system are translated into fixed potentiometer settings of the computer, a small number of variable settings being reserved for aircraft forward velocity and initial flight conditions. The effects of the vortices in the wake of the wing are represented by the outputs of simple electrical filters. For the understanding of the flutter characteristics of an aircraft, say, machine runs are made at several forward velocities, the wing in each run being disturbed initially. Pen traces of the resulting wing oscillations as functions of time yield all required dynamic information. The oscillations diverge above the flutter speed. To illustrate the application, sample results with appropriate numerical comparisons are presented.

The analog computation technique recommends itself by its flexibility and by the large timesaving achieved through its use. Systems with many degrees of freedom and systems containing nonlinear components, both difficult to treat mathematically, can be analyzed by machine with comparative ease.

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See page 35 for Preprints that are immediately available.

A Study of the Nonlinear Characteristics of Compressible Flow Equations by Means of Variational Methods

By

Chi-Teh Wang and G. V. R. Rao

New York University

By means of variational methods, the problem of a steady irrotational compressible flow past an arbitrary body may be solved directly in the physical plane. The resulting equations are nonlinear in nature. A study of these equations is made in this paper. It is found that at high Mach Numbers, the solution may no longer be unique. Beyond a certain limiting Mach Number, no physically possible solution exists. At this limiting value, it is shown that an unsymmetrical flow pattern may appear.

It is also shown that, if only the velocity and pressure distributions on a given profile at various Mach Numbers are to be found, good approximate results may be obtained by the use of the linearized variational integral. Comparisons are made between the linearized and nonlinear solutions in the case of a circular cylinder, a Kaplan's bump, an elliptical cylinder, and a sphere. It is seen that in all these cases the linearized solutions give close agreement to the nonlinear ones. By working with the linearized integral, the labor saved is enormous.

Hypothesis for Skewness of the Probability Density of the Lateral Velocity Fluctuations in Turbulent Shear Flow

By

Stanley Corrsin

The Johns Hopkins University

It is proposed that the observed skewness in the probability density of transverse velocity fluctuations in a turbulent shear flow is due to the corresponding lateral gradient in lateral turbulence intensity. A simple estimate is deduced for small skewness in terms of the turbulence level, its gradient, and a characteristic length, Λ. An order of magnitude comparison is made with experiment by computing Λ and comparing with the dimension of the shear region.

Bifurcation Criterion and Plastic Buckling of Plates and Columns

By

C. E. Pearson

Brown University

If a bifurcation of equilibrium paths occurs as the loading is varied on a conservative system, the preferred path is usually obtained by use of a stability criterion. However, even if the definition of stability is modified so as to no longer depend on the existence of a potential energy function, a stability criterion may not be useful if the system is nonconservative. The choice of a different type of criterion is discussed for the particular case of plastic buckling of plates and columns, and detailed calculations are given for the simplified column model introduced by Shanley.

To find the deflection of a real column with arbitrary cross section in the neighborhood of the tangent modulus load, numerical methods must be used. Two such methods are outlined: One consists of a sequence of approximations to the simultaneous solution of two nonlinear integral equations, and the other consists of a sequence of graphical integrations based on the stress-strain curve of the material. Under certain conditions, a portion of the solution may be found in analytic form.

The problem of plastic buckling of plates under compressive edge thrust has been most rigorously treated by Handelman and Prager. If their calculations are modified by the assumption of initial loading (in analogy with the tangent modulus theory for columns), then their results may be brought into fair agreement with recent experimental work by Pride and Heimerl. The assumption of initial loading may be verified *a posteriori*.

Application of Frequency Response Analysis to Aircraft-Autopilot Stability

By

Charles L. Seacord, Jr.

Georgia Institute of Technology

A description of the frequency-response method for analyzing an aircraft-autopilot combination is given, and examples are used to demonstrate various aspects of the method and the criteria for stability. In particular, one numerical example illustrates the method of calculating the aircraft response curves. The procedure for determining the autopilot response curves is outlined. The use of Nyquist diagrams for the analysis of frequency-response data is discussed, and Nyquist diagrams for the example are correlated with the separate frequency-response curves. The complete longitudinal and lateral equations of motion for an aircraft are presented, and, in addition, certain simplified equations for special cases are included. Sources of information concerning the aerodynamic derivatives are given in tabular form.

Determination of Frequency Characteristics from Response to Arbitrary Input

By

E. R. Walters and J. B. Rea

Douglas Aircraft Company, Inc.

A method is given for determining the frequency response spectrum of a simple dynamic system when an arbitrary driving force (input) and the corresponding response (output) are known. The complex frequency response (transfer function) is determined as the ratio of corresponding terms in the Fourier expansions of the driving force and response. The numerical evaluation of the Fourier coefficient integrals is shown to be equivalent to a simple matrix multiplication. The actual computation may be done rapidly on automatic calculating equipment, and an example has been carried out.

Longitudinal Stability of Autopilot-Controlled Aircraft

By

Andrew Vazsonyi

Naval Ordnance Test Station

The design analysis of autopilots for subsonic and supersonic aircraft is presented. The aerodynamic equations are written in a concise operational form with the aid of a new set of aerodynamic coefficients which has immediate bearing on the dynamics of the aircraft. Study of the uncontrolled aircraft is presented first, then the analysis of a proportional type control is given. The final analysis contains a properly tuned computer between the sensing element and the autopilot, which is assumed to have a simple time lag. Numerical examples are presented for both a subsonic and a supersonic aircraft. The analysis is based on the transient behavior of the system and is further substantiated by transients obtained with the aid of an analog computer.

A Theoretical Investigation of Heat Transfer in the Laminar Flow Regions of Airfoils

By

Leonard Goland

Cornell University

An analysis is presented of the thermal boundary layer about a certain infinite cylinder having a chordwise pressure gradient. An incompressible fluid of Prandtl Number equal to unity is considered. The thermal boundary-layer profiles are obtained at various chordwise stations and are shown to differ appreciably from the existing velocity boundary-layer profiles. The method of solution is analogous to that used by Sears in calculating the spanwise flow in the boundary layer of a yawed infinite cylinder. Although use of this method is not feasible for an arbitrary cylinder, it presents

a case in which the results of more approximate methods may be evaluated. Consequently, the heat transfer from the cylinder is calculated by several commonly used methods and is compared to the more exact solution.

The results indicate that, of several available approximate methods applicable to the estimation of heat transfer in this case, only the one proposed by Squire gives good agreement with the more exact results.

Increased Jet Thrust from Pressure Forces

F. P. Durham

University of Colorado

For ram-jets and turbojets, which operate with low overall jet expansion ratios, it is possible to obtain more thrust with incomplete expansion in the jet nozzle utilizing both pressure and momentum forces than with complete expansion utilizing momentum forces alone. Proof of this phenomenon is developed, and charts are introduced showing the range of pressure ratios and velocity coefficients for which incomplete expansion will produce greater thrust than complete expansion.

Development of High-Speed Water-Based Aircraft

By

Ernest G. Stout

Consolidated Vultee Aircraft Corporation

Outstanding progress has been made in recent years in the field of seaplane hydrodynamics which has done much to bring the faltering seaplane up to modern standards of aerodynamic performance and design efficiency. In fact, extensive research programs, utilizing the dynamically similar model technique, promise to place consideration of water based aircraft high on the program of current defense planning.

This paper outlines the salient features involved in the development of the dynamic model and associated research techniques into a practical, accurate research tool for designing water-based aircraft that demand little, if any, compromise with contemporary aerodynamic design. New seaplane design criteria are discussed, and their application to high-performance water-based aircraft is analyzed. With the high-speed propeller-driven seaplane now an actuality, attention is drawn to the solution of the supersonic water-based problem.

It is concluded that adequate design criteria and technological experience are available to meet satisfactorily or to exceed any aircraft requirement with a suitable water-base configuration.

Base Drag and Thick Trailing Edges

By

Sighard F. Hoerner

Air Materiel Command, Wright-Patterson Air Force Base

The negative pressure, originating behind the flat base of projectiles, presents a drag component that is consequently termed "base drag." As illustrated in Fig. 1, the same kind of drag exists for every elongated body, the flow around which is separated from its rear side, such as airfoil sections the trailing edges of which are cut off or thickened. The same type of drag is also found behind certain sheet-metal joints. It is possible to correlate all the various base drags with each other by considering the effect of the boundary layer originating from the forebodies. Analyzing competent measurements, simple formulas are found with which to calculate the drag, among others, of tail turrets and blunt trailing wing edges. In the case of thicker sections, such as are used for the blade roots of propellers, the lift is also affected and the lift-drag ratio can be improved remarkably by thickening the trailing edge. At supersonic speeds the base drag approaches the natural limit as given by zero pressure (vacuum). Depending upon the body shape, the base pressure assumes an approximately constant percentage of the theoretical limit.

Transient Loading of Supersonic Rectangular Airfoils

By

John W. Miles

University of California at Los Angeles

The results of earlier papers are used to calculate the lift and moment coefficients for a rectangular airfoil that experiences a sudden change in angle of attack in an otherwise uniform supersonic stream or which enters a sharp-edged gust. The results are valid when the Mach lines from the leading-edge corners do not intersect the opposite side edges. Numerical results are given in the form of curves.

Note on Free Turbulent Flows with Special Reference to the Two-Dimensional Wake

By

G. K. Batchelor

Trinity College, Cambridge, England

For some time past there has been a growing realization that the mixing-length theory of turbulent shear flow is neither empirically nor logically sound. However, without considerable guidance from experimental research it is difficult to replace it. This paper reviews some of the measurements concerning free turbulence which have been made by Townsend at Cambridge in recent years and which exhibit several weaknesses of the mixing-length theory. It is possible to infer from the measurements the general mechanism of transfer of momentum and of quantities like turbulent energy and heat, although a corresponding analytical theory has not yet been formulated.

Column Buckling in the Elastoplastic Range

By

P. Cicala

Instituto Aerotécnico and University of Cordoba, Argentina

A theory of inelastic buckling of a column of constant, H-shaped section is presented and an approximate procedure of solution indicated. The numerical application confirms qualitatively the results found by Shanley on the idealized semirigid strut. On this last simplified scheme the effect of initial eccentricities is investigated and Southwell's plot analyzed. Considering the curvature of the stress-strain characteristic, it appears that, in accordance with experimental observations, the load decreases with increasing deflections after reaching a value that, for small initial eccentricities, may not attain the tangent-modulus value.

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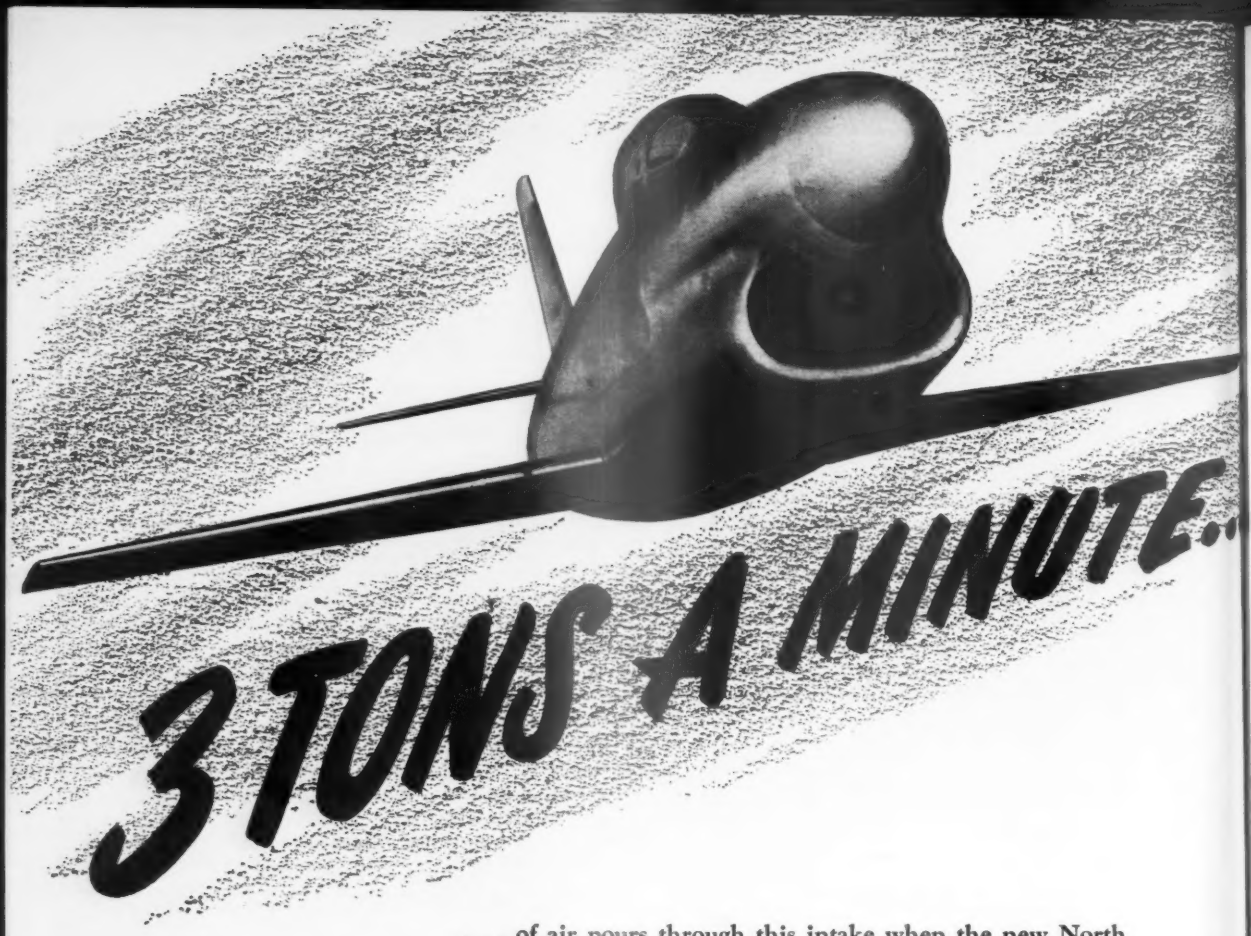

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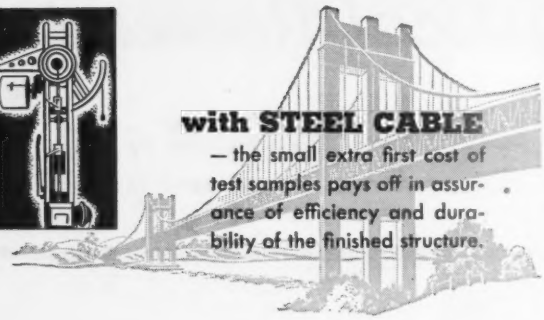

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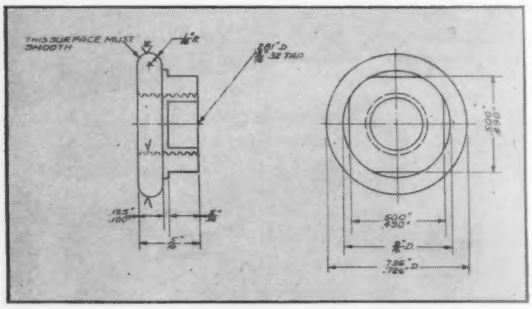

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Aerodynamics (2)

AERODYNAMIC LOADS

Notes on Some Aspects of Tail Buffeting. E. W. Graham. *Douglas Aircraft Company, Inc., Report No. SM-13664,* November 22, 1949. 8 pp., illus. 4 references.

A method for the production of flow fluctuations and tail buffeting which uses the von Kármán vortex trail as a first approximation to the wake behind a two-dimensional wing on which a flow separation has occurred. The unsteady flow of the vortex trail relative to the airplane is assumed to be one possible source of buffeting, and expressions are obtained for the velocities induced by the vortex trail. If the vortex trail is replaced by a wave-shaped wall moving through the fluid with the velocity of the vortex system, the resulting disturbances decay exponentially with the distance from the wall, but the decay is less rapid at high Mach Number. Since the Mach Number involved is the same as that of the vortex trail, which is less than the airplane Mach Number, that particular effect appears to be small for subsonic airplane velocities.

BOUNDARY LAYER

Steady Flow in the Laminar Boundary Layer of a Gas. C. R. Illingworth. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences,* Vol. 199, No. 1059, December 7, 1949, pp. 533–558. 11 references.

If the boundary-layer equations for a gas are transformed by Mises's transformation, the computation of solutions is simplified and previous solutions for an incompressible fluid may be used. For any value of the Prandtl number and any variation of the viscosity with the temperature, after the method has been applied to flow along a flat plate, the flow near the forward stagnation point of a cylinder is calculated with dissipation neglected, both with the effect of gravity on the flow neglected and with this effect retained for vertical flows past a horizontal cylinder. The cross drift is calculated when a horizontal stream flows past a vertical surface. When the Prandtl number is unity, the viscosity is proportional to the temperature, and the boundary is heat insulated, then the boundary-layer equations for a gas may be made identical, whatever the main stream, with the boundary-layer equations for an incompressible fluid with a certain, determinable main stream.

Correlated Incompressible and Compressible Boundary Layers. K. Stewartson. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences,* Vol. 200, No. 1060, December 22, 1949, pp. 84–100, illus. 7 references.

The boundary-layer equations for a compressible fluid are transformed into those for an incompressible fluid, assuming that the boundary is thermally insulating, that the viscosity is proportional to the absolute temperature, and that the Prandtl number is unity. Various results in the theory of incompressible boundary layers are then taken over into the compressible theory. The existence of 'similar' solutions is proved, and Howarth's method for retarded flows is applied to determine the point of separation for a uniformly retarded main stream velocity. A comparison with an exact solution is used to show that this method gives a closer approximation than Pohlhausen's.

Some Remarks on the Flat Plate Boundary Layer. J. A. Lewis and G. F. Carrier. *Quarterly of Applied Mathematics,* Vol. 7, No. 2, July, 1949, pp. 228–234. 2 references.

A Note on Boundary-Layer Type Solutions in Applied Mechanics. S. F. Borg. *Journal of the Aeronautical Sciences,* Vol. 17, No. 4, April, 1950, pp. 253–255. 9 references.

Équations Fondamentales de la Couche Limite Laminaire ou Turbulent en Fluide Compressible; La Plaque Plane dans le Cas Laminaire. Adalbert Oudart. *France, Ministère de l'Air, Publications Scientifiques et Techniques, No. 221,* 1948. 144 pp., illus. 53 references. Service de Documentation et d'Information Technique de l'Aéronautique, Paris. 845 Fr.

CONTROL SURFACES

Supersonic Tests of Conventional Control Surfaces on a Double-Wedge Airfoil. Michael Pindzola. *Journal of the Aeronautical Sciences,* Vol. 17, No. 4, April, 1950, pp. 204–210, illus. 3 references.

Alette Freno. R. Gatti. *L'Aerotecnica,* Vol. 29, No. 4, August 15, 1949, pp. 215–223, illus. 5 references.

FLUID MECHANICS

The Supersonic Flow Past a Slender Ducted Body of Revolution with an Annular Intake. G. N. Ward. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 4, February, 1950, pp. 305–318, illus. 2 references.

The approximate supersonic flow past a slender ducted body of revolution having an annular intake is determined by using the Heaveside operational calculus applied to the linearized equation for the velocity potential. It is assumed that the external and internal flows are independent. The pressures on the body are integrated to find the drag, lift, and moment coefficients of the external forces. The lift and moment coefficients have the same values as for a slender body of revolution without an intake, but the formula for the drag has extra terms. Under extra assumptions, the lift force due to the internal pressures is estimated. The results are applicable to propulsive ducts working under the specified condition of no "spill-over" at the intake.

Unsteady Compressible Flow in Two Dimensions. T. V. Davies. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 199, No. 1059, December 7, 1949, pp. 468–486, illus. 2 references.

The paper presents an alternative to the well-known linear perturbation theory of two-dimensional compressible flow by superposing a small perturbation upon the correct basic irrotational flow pattern. When the latter is known, the perturbation field is determined by partial differentiation of a function which satisfies a linear partial differential equation of the second order. A particular example of the theory is investigated in which the basic flow is circular and bounded internally by an oscillating circular cylinder, and the author restricts himself to the problem of wave propagation.

Studies on Two-Dimensional Transonic Flows of Compressible Fluid. I. S. Tomotika and K. Tamada. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 381–397, illus. 5 references.

Starting from the equations of motion, in two dimensions, of a compressible perfect fluid, a partial differential equation is obtained for the flow of a hypothetical gas that approximates a real gas, subject to the adiabatic law, in the vicinity of the critical state. Although the form of the differential equation is simple, it retains the nonlinearity of the original equations and changes from an elliptic to a hyperbolic equation when the fluid velocity exceeds the speed of sound. It provides an exact analysis of the transition from a flow that is subsonic on both sides of the throat of a Laval nozzle but contains limited supersonic regions at the walls of the constriction, to a flow that changes from subsonic to supersonic as it passes through the throat.

Transonic Drag of an Accelerated Body. M. A. Biot. *Quarterly of Applied Mathematics*, Vol. 7, No. 1, April, 1949, pp. 101–105, illus. 1 reference.

The drag of an accelerated two-dimensional wedge at the speed of sound depends on the ratio of the length of the body to the distance traveled from rest to reach the speed of sound. The presence of an acceleration causes a finite drag in contrast to the infinite drag that obtains in the steady case. As the value of the acceleration decreases, the drag tends to infinity as the inverse fourth root of the acceleration. In contrast to the steady case, there is a concentration of infinite pressure at the nose which indicates that the lift distribution on an accelerated wing will introduce a stalling moment in going through the speed of sound.

Degenerate Two-Dimensional Non-Steady Irrotational Flows of a Compressible Gas. N. Coburn. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 439–443. 1 reference.

A Canonical characteristic system of five equations with five dependent variables and two independent variables is obtained for flows that have two families of cylindrical characteristic surfaces (with generators parallel to the time axis) existing in space-time. These degenerate flows have stationary wave fronts. Each of their velocity components and the speed of sound depend on a single function of the time which is such that the motion decays as time increases. Simple waves are shown not to exist, and a degenerate nonsteady flow does exist whose stream lines are logarithmic spirals.

The Linear-Perturbation Theory for Rotational Flow. W. R. Sears. *Journal of Mathematics and Physics*, Vol. 28, No. 4, January, 1950, pp. 268–271. 5 references.

The force on a body immersed in a compressible flow can be related to the force that acts in the corresponding incompressible case. The rule relating the forces in the incompressible and the associated compressible flows is the same as for irrotational flow. These forces will not be affected by the vorticity to the first order nor will there appear a first-order drag.

A New Superposition Principle for Steady Gas Flows. R. C. Prim. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 445–450. 7 references.

An investigation of the spatial reduced velocity fields that can be obtained by a combined application of the Substitution Principle and Newtonian relativity considerations to a plane flow field.

Readers' Forum: Another Note on the Velocity of Sound. C. B. Millikan. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, p. 252. 1 reference.

Readers' Forum: Remarks on the Interaction Between Parallel Streams of Subsonic and Supersonic Velocities. Mac C. Adams. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, p. 250, illus. 1 reference.

Champ Sonore Produit par une Source Ponctuelle en Movement Rectiligne Uniform dans un Fluide Parfait, Spécialement dans le Cas d'une Vitesse Supersonique. P. Lienard. *La Recherche Aéronautique*, No. 10, July-August, 1949, pp. 43–51, illus.

Détermination des Charactéristiques d'un Fluide Parfait pour Diverses Combinasions d'Onde de Choc en Écoulement Plan. J. Nicolas and H. Audic. *La Recherche Aéronautique*, No. 7, January-February, 1949, pp. 51–58, illus.

Étude des Régimes Transitoires en Aérodynamique Supersonique à Deux Dimensions; Aperçu Théorique sur le Domaine Transsonique. Ch. Roumieu. *La Recherche Aéronautique*, No. 9, May-June, 1949, pp. 47–54, illus. 9 references.

A Note on Supersonic Flow in the Trefftz Plane. John W. Miles. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 470–472, illus. 5 references.

Application of the W.K.B. Method to the Flow of a Compressible Fluid. II. Isao Imai and Hidenori Hasimoto. *Journal of Mathematics and Physics*, Vol. 28, No. 4, January, 1950, pp. 205–214, illus. 13 references.

Analysis of the flow past a flat plate accompanied with a dead water region, past a circular cylinder, and past an elliptic cylinder. The method furnishes a good approximation with comparatively little work.

Méthode Rapide de Détermination des Charactéristiques d'Un Écoulement Gazeux à Grande Vitesse. J. Fabri. *France, Office National d'Études et de Recherches Aéronautiques, Publication No. 17*, 1948. 51 pp., illus. 8 references.

Supersonic Flow over Bodies of Revolution. Mark Lotkin. *Quarterly of Applied Mathematics*, Vol. 7, No. 1, April, 1949, pp. 65–74, illus. 2 references.

A determination of the flow of a compressible fluid about the head of a pointed body of revolution in which the actual flow may be approximated by a perturbation of the conical flow about the tip of the body. This assumption holds for contours of small curvature. The flow is also assumed to be steady and axially symmetrical. Viscosity, heat conduction, and external forces are negligible. However, since the entropy perturbation is of the same order as the velocity perturbation, it must be taken into account.

The Pressure on a Slender Body of Non-Uniform Cross-Sectional Shape in Axial Supersonic Flow. Ernest W. Graham. *Douglas Aircraft Company, Inc., Report No. SM-13346-A*, July 20, 1949. 16 pp., illus. 4 references.

The linearized theory is used to determine, for slender bodies in axial flow, the order of magnitude of the pressure and drag arising from lack of rotational symmetry. The body is a circular cylinder extending an infinite distance upstream which, with no change in total area, has a part of its length gradually distorted in cross section to a two-lobed shape at the downstream end. The series of shapes undergone in the transition from circular to two-lobed form is fixed, but the rate of transition, as a function of displacement in the downstream direction, may be varied. The formula for pressure coefficient shows the dependency on rate of change of shape and also indicates that the pressure coefficient is proportional to the square of the thickness ratio of distorted element. Since the expressions used for the perturbation velocities are independent of Mach Number, the analysis applies to transonic and subsonic flows as well as to the supersonic case. Hence, within its limits of accuracy, the linearized theory for slender bodies predicts zero wave drag for distorted elements ending in cylinders. In general, altering only the cross-sectional shape of a body of

revolution, but not the area, does not change the drag if the body ends in a cylinder or a point.

On the Axially Symmetric Flow Around a New Family of Half-Bodies. A Van Tuyl. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 399–409, illus. 8 references.

A combined numerical and analytical study of the stream surfaces produced in a perfect incompressible fluid by a uniform disc-source at right angles to a uniform parallel flow from infinity when the radius of the disc increases from zero to its upper limiting value, both the total source strength and the velocity at infinity being held constant. A set of graphs is obtained by means of which the nose of any given profile can be plotted, and curves will show the position and magnitude of the maximum velocity on the surface as functions of the half-body.

The Steady Circulatory Flow About a Circular Cylinder with Uniformly Distributed Suction at the Surface. J. H. Preston. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 4, February, 1950, pp. 319–338, illus. 4 references.

Exact solutions are obtained for the steady circulatory flow about a circular cylinder with suction applied at its surface for cases where the cylinder is at rest and there is circulation at infinity; where the cylinder rotates and there is no circulation at infinity; and where the cylinder rotates in either direction with a circulation at infinity, provided that, in general, the suction velocity is greater than a certain limiting value. An exception occurs when the circulation at the cylinder equals that at infinity, for which it is found that the velocity distribution is independent of suction Reynolds Number and the circulation is independent of radius. The addition of a uniform stream parallel to the cylinder axis does not affect the circulatory motion, and the solution for the combined flow has some practical interest through demonstrating that the boundary layer on a long, circular rotating boss can be kept thin, and that the circulatory motion outside the boundary layer can be prevented by the suitable application of suction before starting the rotation.

The Behaviour of Supersonic Flow Past a Body of Revolution, Far from the Axis. G. B. Whitham. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 201, No. 1064, March 7, 1950, pp. 89–109, illus. 5 references.

A theory of supersonic compressible flow past a body of revolution at large distances from the axis where a linearized approximation is valueless because of the divergence of the characteristics at infinity. The asymptotic forms are found of the equations of shocks arising in the neighborhood of the nose and of the tail. In the special case of a slender pointed body, the general theory at large distances is used to modify the linearized approximation in order to obtain a theory that is uniformly valid at all distances from the axis.

Hot-Wire Investigation of the Wake Behind Cylinders at Low Reynolds Numbers. L. S. G. Kovasznay. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 198, No. 1053, August 15, 1949, pp. 174–190, illus. 8 references.

The hot-wire technique has been used to measure the regular vortex street pattern behind a cylinder at low Reynolds Number. Measurements of mean velocity distribution were made both below and above the critical Reynolds Number at which the periodic motion appears. Amplitude and phase measurements gave sufficient information for computation of the instantaneous flow pattern of the vortex system. The critical Reynolds Numbers at which vortices are shed is 40. In the range of Reynolds Numbers investigated, the vortices are not shed directly from the cylinder but appear some distance downstream as an instability of the laminar wake.

On Heisenberg's Elementary Theory of Turbulence. S. Chandrasekhar. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 200, No. 1060, December 22, 1949, pp. 20–33, illus. 3 references.

The spectrum of turbulence is considered on the basis of an elementary theory developed by Heisenberg. Explicit solutions for the spectrum have been obtained both when an equilibrium spectrum obtains and when the turbulence is decaying. In the former case, the problem admits of an explicit solution. In the latter case, the problem reduces to determining a one-parametric family of solutions of a certain second-order differential equation. The decay spectra for various values of the Reynolds Number, which remains constant during the decay, are illustrated.

Note on the Characteristics in Unsteady One-Dimensional Flows with Heat Addition. C. C. Lin. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 443–445, illus. 1 reference.

A derivation of the characteristic equations of a flow in which there is one-dimensional wave propagation when heat is being added. The proper choice of the dependent variables simplifies the equations and permits numerical integration, by taking finite differences along the characteristics, to be carried out in a straightforward manner.

The Thickness of a Shock Wave in Air. A. E. Puckett and H. J. Stewart. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 457–463, illus. 9 references.

Using a thermally perfect gas and the linear theories of the viscous stress tensor and the heat flux vector, the width of the shock wave in air is calculated for Prandtl number 0.75, with the physical parameters given as functions of the absolute temperature. If the variation of the physical parameters is taken into account, the shock-wave width, even for the limiting case of an infinitely strong shock wave, is found to be several molecular free paths, which greatly reduces but does not eliminate the importance of the Burnett stresses and the deviations from thermodynamic equilibrium.

Momentum and Energy Diffusion in the Turbulent Wake of a Cylinder. A. A. Townsend. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 197, No. 1048, May 11, 1949, pp. 124–140, illus. 16 references.

Downstream of a cylinder placed in an air stream, direct measurements were made of the mean flow velocity, turbulent intensity, viscous dissipation, energy diffusion, and of scale and form factors of the velocity components and their spatial derivatives. Except close to the wake center, the flow at a fixed point with respect to the cylinder is only intermittently turbulent because of the passage of the point of observation through jets or billows of turbulent fluid emitted from the inner body of the wholly turbulent core of the wake. The turbulent motion within the jets is solely responsible for the turbulent transfer of momentum. The turbulent energy of heat is diffused by the bulk movement of the jets. The turbulent motion consists of a motion of small scale compared with the mean flow superimposed on a slower turbulent motion whose scale is large compared with the mean flow. A formal explanation of the two-stage turbulent structure may be made in terms of a Fourier representation of the velocity field, which relates the structure to the presence of a quasi-constant source of energy of nearly fixed wave number and to the free boundary, which allows an unlimited range of wave numbers.

The Nature of Turbulent Motion at Large Wave-Numbers. G. K. Batchelor and A. A. Townsend. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 199, No. 1057, October 25, 1949, pp. 238–255, illus. 15 references.

Measurements were made which describe the distribution of turbulent energy over Fourier components of large wave number. Over part of the wave-number range the form of the spectrum is predicted by a dimensional argument, but at higher wave numbers the spectrum depends on the manner in which energy is transferred across the spectrum. Heisenberg's postulate alone leads to a spectrum function that can be consistent with the measurements. This consistency is obtained by postulating that there is an upper limit to the range of wave numbers containing energy. This limit corresponds to a critical Reynolds Number below which no energy transfer occurs and the motion is "laminar." Oscillograms of the velocity derivatives show that the energy associated with large wave numbers is unevenly distributed in space. There appear to be isolated regions in which the large wave numbers are "activated," separated by regions of comparative quiescence. This spatial inhomogeneity becomes more marked with increase in the order of the velocity derivative.

Solutions of the Equations for the Non-Uniform Propagation of a Very Strong Shock Wave. W. P. Robbertse and J. M. Burgers. (*Delft, Technische Hoogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 63*, October 29, 1949.) *Netherlands, Koninklijke Nederlandsche Akademie van Welenschappen, Proceedings*, Vol. 52, Nos. 9, 10, 1949. 16 pp., illus. (In English.) (Reprint.)

A solution for certain special distributions of the density of a gas, based on the assumption of a specific expansion of the individual layers of the gas, is extended to cases where the shock wave

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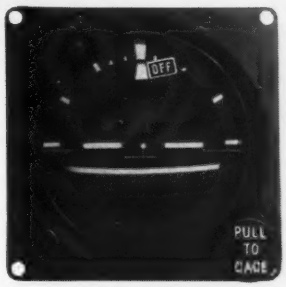

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propagates itself with increasing velocity through a gas with decreasing density. The complicated boundary condition to be satisfied at the shock wave was replaced by a simpler condition, leading to a more convenient procedure for solving the equations. When the density is constant, solutions based on a given specific expansion of the gas volume cannot be made exactly to satisfy the equation of motion and the conditions to be fulfilled at the shock wave, but an approximation was obtained that appeared to be satisfactory. If the density is variable, a solution can be found that exactly satisfies both the equation of motion and the boundary condition at the shock wave.

Les Mouvements Tourbillonnaires en Régime Transitoire. Marcel Tournier and Marc Bassière. *France, Office National d'Études et de Recherches Aéronautiques, Publication No. 16*, 1948. 42 pp., illus.

Kinetic Theory of Diffusion in Gases and Liquids. I—Diffusion and the Brownian Motion. L. M. Yang. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 198, No. 1052, July 22, 1949, pp. 94–116. 9 references.

When the coefficients of self-diffusion, ordinary diffusion, and thermal diffusion are expressed in terms of the first and second moments of transition probabilities of the theory of Brownian motion, it is possible, in gases of low or moderate density where a fairly well-defined free path exists, to follow the future course of a given molecule statistically to as many free flights as required, provided the velocity distribution of the molecules in the medium is known. This treatment leads to a rigorous expression for the coefficient of self-diffusion directly calculated from a Maxwellian distribution. It also clarifies the relation between the free-path theory of gaseous diffusion and the rigorous theory of gaseous diffusion and the relation between self-diffusion and mutual diffusion.

Pressure Distribution and Some Effects of Viscosity on Slender Inclined Bodies of Revolution. H. Julian Allen. *U.S., N.A.C.A Technical Note No. 2044*, March, 1950. 19 pp., illus. 10 references.

Note on the Kinematics of Plane Viscous Motion. J. L. Synge. *Quarterly of Applied Mathematics*, Vol. 8, No. 1, April, 1950, pp. 107, 108. 1 reference.

Solution of the Differential Equations of Motion of a Projectile in a Medium of Quasi-Newtonian Resistance. Harry Polachek. *Quarterly of Applied Mathematics*, Vol. 7, No. 3, October, 1949, pp. 275–291, illus. 2 references.

A solution for the differential equations of motion of a body in a medium in which the resistance law is almost Newtonian is obtained by using the theory of differential variations which takes into account differentials of the first order only. The methods are sufficiently general to be applicable, with slight modifications, to any resistance law for which a solution to the equations of motion can be obtained in finite form.

Readers' Forum: The Extension of the Prandtl-Glauert Rule. E. V. Laitone. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, pp. 250, 251. 9 references.

Captation par un Corps de Révolution; Application à la Sphère. M. Vasseur. *La Recherche Aéronautique*, No. 9, May–June, 1949, pp. 61–64, illus. 3 references.

Aerodynamique Moleculaire. I, II. Michel Luntz. *La Recherche Aéronautique*, Nos. 7, 8, January–February, March–April, 1949, pp. 17–33; 9–12; illus. 9 references.

INTERNAL FLOW

The Passage of a Perfect Fluid Through a Critical Cross-Section or "Throat." A. M. Binnie. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 197, No. 1051, September 7, 1950, pp. 545–555, illus. 16 references.

Hugoniot's method is used to examine the discharge of a liquid through a Venturi flume of any shape and the flow of a swirling gas through a nozzle. If an external force is operating in an axial direction, the local velocity of sound or of a long wave, as the case may be, is not attained by the fluid at the exact geometrical throat of the constriction.

The Supersonic Flow of Compressible Fluid Through Axially Symmetric Tubes of Uniform and Varying Section. R. K. Tempest. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 200, No. 1063, February 22, 1950, pp. 511–523, illus. 8 references.

The velocity potentials of the supersonic flow of a compressible, inviscid fluid in axially symmetrical tubes or diffusers are expressed as series of Bessel functions. General formulas determine the linearized flows completely when the inlet distributions of velocity are known, in cases where the slope of the nozzle wall is continuous, and where there are no discontinuities in the velocity field or in the rates of change of velocity. Formulas are also given for the tabulation of a wide class of axisymmetric parabolic and nonparabolic flows.

On Steady, Laminar Two-Dimensional Jets in Compressible Viscous Gases Far Behind the Slit. M. Z. Krzywoblocki. *Quarterly of Applied Mathematics*, Vol. 7, No. 3, October, 1949, pp. 313–323. 3 references.

An outline of a method of solution of the problem of a laminar, steady, two-dimensional jet in a compressible viscous fluid flowing through a narrow slit in the wall and then mixing with the surrounding medium that is at rest, which takes into account the equations of motion, continuity, energy, and state. The coefficients of viscosity and the thermal conductivity are assumed to be functions of temperature. The velocity distribution and the density can be found far behind the slit.

On Heat Transfer Problems in Viscous Flow. G. F. Carrier and J. A. Lewis. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 450–457. 2 references.

A method of classification techniques for the determination of the temperature distribution throughout the field of flow of a viscous fluid flowing through a narrow channel when a thermal boundary layer exists, when the temperature distribution is independent of the coordinate across the channel, and when there is an intermediate type of temperature distribution.

Some Exact Solutions of the Flow Through Annular Cascade Actuator Discs. Stephen L. Bragg and William R. Hawthorne. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, pp. 243–249, illus. 5 references.

Method of Experimentally Determining Radial Distributions of Velocity Through Axial-Flow Compressor. Harold B. Finger. *U.S., N.A.C.A., Technical Note No. 2059*, April, 1950. 25 pp., illus. 6 references.

Analysis of Factors Influencing the Stability Characteristics of Symmetrical Twin-Intake Air-Induction Systems. Norman J. Martin and Curt A. Holzhauser. *U.S., N.A.C.A., Technical Note No. 2049*, March, 1950. 16 pp., illus.

Two-Dimensional Symmetrical Inlets with External Compression. P. Ruden. (*ZWB, Forschungsbericht Nr. 1209*, April 15, 1940.) *U.S., N.A.C.A., Technical Memorandum No. 1279*, March, 1950. 48 pp., illus. 3 references.

Feuille de Travail. III—Résistance des Tubes. A. Tonski. *La Recherche Aéronautique*, No. 10, July-August, 1949, pp. 53–56, illus. 6 references.

The Flow Under Gravity of a Swirling Liquid Through an Orifice-Plate. A. M. Binnie and J. F. Davidson. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 199, No. 1059, December 7, 1949, pp. 443–457, illus. 10 references.

NATURAL FLIGHT

Dettagli sui Comandi del Viberti "Musca 1." Franco Conte. *L'Ala* (Italy), Vol. 5, No. 2, January 15, 1949, p. 5, illus.

STABILITY & CONTROL

Dynamic Stability at High Speeds from Unsteady Flow Theory. I. C. Statler. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, pp. 232–242, 255, illus. 17 references.

Dynamic Similitude Between a Model and a Full-Scale Body for Model Investigation at Full-Scale Mach Number. Anshal I. Neihouse and Philip W. Pepoon. *U.S., N.A.C.A., Technical Note No. 2062*, March, 1950. 8 pp. 1 reference.

Proposals for Lightplane Stability; NACA Experiments on Simple Way to Center Controls, Avoiding Job of Lessening Control System Friction. *Aviation Week*, Vol. 52, No. 14, April 3, 1950, pp. 32, 34, 36, illus.

The Effect of Rate of Change of Angle of Attack on the Maximum Lift of a Small Model. Paul W. Harper and Roy E. Flanigan. *U.S., N.A.C.A., Technical Note No. 2061*, March, 1950. 20 pp., illus. 1 reference.

Algemeene Beschouwingen Inzake de Langsstabiliteit en Besturing van Staartlooze Vliegtuigen. II, III. A. J. Marx and J. Buhrman. *Netherlands, Nationaal Luchtvaartlaboratorium,*

Amsterdam, Rapport Nrs. V.1400, V.1401, April 18, October 17, 1944. 52; 55 pp.; illus. 15 references. (In Dutch.)

WINGS & AIRFOILS

An Empirical Method for Rapidly Determining the Loading Distributions on Swept Back Wings. R. Stanton Jones. *College of Aeronautics, Cranfield, England, Report No. 32*, January, 1950. 39 pp., illus. 77 references.

The derivation of empirical formulas for the loading distribution on straight tapered swept-back wings in terms of the parameters governing the geometric wing plan form is based mainly on the results of Weissinger method, with corrections to give better agreement with experimental results. The new method depends on the assumption that the shape of the loading curve can be completely defined by the position of the spanwise center of pressure and can be expressed exactly in a formula involving the spanwise center of pressure. The formula can be used to derive the loading distribution for any wing designed within a wide range of aspect ratio, taper ratio, and sweepback angle, and the calculation can be completed in a few minutes with accuracy comparable with that of the Falkner method. The method permits the easy incorporation of the results of the linear perturbation theory of compressible flow, but it suffers from the limitation that it applies only to simple trapezoidal wing plan forms.

On the Application of Oblique Coordinates to Problems of Plane Elasticity and Swept Back Wing Structures. W. S. Hemp. *College of Aeronautics, Cranfield, England, Report No. 31*, January, 1950. 41 pp., illus.

Formulas are derived to express the fundamental concepts and relations of geometry, kinetics, statics, and plane elasticity in terms of vector components in oblique coordinates. The results are applied to a uniform, symmetrical, rectangular-section, swept-back box structure, in order to obtain a complete theory of stress distribution and deflections for the case of loading by normal forces and couples applied to the ends of the box in which consideration is also given to problems of constraint against warping. The main results are generalized to cover a more representative wing structure, by extending the usual theory of bending and torsion to the case of sweptback wings with ribs parallel to the direction of flight. Procedures, based on that extension, for calculations of stress distribution and deflection will have the same validity for sweptback wings as the usual design approximations for the case of unswept wings.

The Reversal Theorem of Linearized Supersonic Airfoil Theory. M. M. Munk. *Journal of Applied Physics*, Vol. 21, No. 2, February, 1950, pp. 159–161. 3 references.

A supersonic airfoil under certain conditions exhibits the same drag and the same lift slope regardless of whether it flies forward or backward.

A Note on a Solution to Possio's Integral Equation for an Oscillating Airfoil in Subsonic Flow. John W. Miles. *Quarterly of Applied Mathematics*, Vol. 7, No. 2, July, 1949, pp. 213–216. 11 references.

A method for solving the integral equation for an oscillating airfoil in a subsonic compressible flow, which is analogous to that used by Schwarz for the incompressible case.

Readers' Forum: On Downwash Corrections in Unsteady Flow. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, p. 253. 3 references.

Tables of Wing-Aileron Coefficients of Oscillating Air Forces for Two-Dimensional Supersonic Flow. Vera Huckel and Barbara J. Durling. *U.S., N.A.C.A., Technical Note No. 2055*, March, 1950. 73 pp., illus. 2 references.

Velocity Distribution on Wing Sections of Arbitrary Shape in Compressible Potential Flow. III—Circulatory Flow Obeying the Simplified Density-Speed Relation. Lipman Bers. *U.S., N.A.C.A., Technical Note No. 2056*, March, 1950. 36 pp., illus. 12 references.

Characteristics of Low-Aspect-Ratio Wings at Supercritical Mach Numbers. John Stack and W. F. Lindsey. *U.S., N.A.C.A., Report No. 922*, 1949. 6 pp., illus. 7 references. U.S. Govt. Printing Office, Washington. $0.10.

A Method of Computing Subsonic Flows Around Given Airfoils. Abe Gelbart and Daniel Resch. *U.S., N.A.C.A., Technical Note No. 2057*, March, 1950. 34 pp., illus. 17 references.

Pressure Distribution and Damping in Steady Roll at Supersonic Mach Numbers of Flat Swept-Back Wings with Subsonic Edges. Harold J. Walker and Mary B. Ballantyne. *U.S., N.A.C.A., Technical Note No. 2047*, March, 1950. 57 pp., illus. 9 references.

Theoretical Lift and Damping in Roll of Thin Sweptback Tapered Wings with Raked-In and Cross-Stream Wing Tips at Supersonic Speeds; Subsonic Leading Edges. Kenneth Margolis. *U.S., N.A.C.A., Technical Note No. 2048*, March, 1950. 37 pp., illus. 14 references.

La Théorie des Mouvments Homogénes et son Application au Calcul de Certaines Ailes Delta en Régime Supersonique. P. Germain. *La Recherche Aéronautique*, No. 7, January-February, 1949, pp. 3–16, illus. 7 references.

Le Comportement de l'Aile aux Grands Angles; Le Décrochage en Envergure. M. Chaffois. *Technique et Science Aéronautiques*, No. 6, 1948, pp. 313–328, illus.

Airplane Design & Description (10)

A Review of Aerodynamic Cleanness. E. J. Richards. *Royal Aeronautical Society, Journal*, Vol. 54, No. 471, March, 1950, pp. 137–172, Discussion, pp. 172–186, illus. 25 references.

An analysis of the overall gains in aerodynamic cleanness and a review of the performance improvement to be expected in advanced concepts intended to achieve lower drag coefficients and better performance. The study is confined to large transport aircraft flying below their critical Mach Numbers and leaves out compressibility effects, except by implication. At present, laminar flow offers the greatest potential savings in drag, giving two- and threefold gains in pay load. Severe losses arise from induced and profile drag or incorrect sweepback, but well designed proturberances, such as bubble cockpits, need not be inferior to the flush-cabin design. Good interior airflow is as important as good external characteristics. For the future, the attainment of laminar flow to the 50 per cent of chord point on long-range aircraft should practically double the pay load, and the flying-wing layout can increase the gain by another 50 per cent. Thin Griffith wings and thick suction wings of orthodox layout show little or no advantage over the normal pusher form with far-back transition points, although the thick suction wing principle is suitable for flying-wing layouts that offer quadrupled pay load and nearly tripled range, if transition at the slot is provided.

The Weight Aspect in Aircraft Design. L. W. Rosenthal. *Royal Aeronautical Society, Journal*, Vol. 54, No. 471, March, 1950, pp. 187–200, Discussion, pp. 200–210, illus. 8 references.

Weight saving has been accomplished in a haphazard manner in the past being left largely to the structures designer. Power plant and equipment account for 33 per cent of the total weight of a modern civil airplane, exceeding the 27 per cent allocated to the structure. Accessories and equipment can be reduced as much as 60 per cent in weight by proper design. The use of gas turbines has made possible great weight reduction, and further progress can be made by using lighter castings and lighter fire-protection equipment. The complete weight of items such as stringers and plating should be considered instead of the specific weight. Structural efficiency should achieve the minimum weight of structure to carry given loads, while design efficiency reduces to a minimum the loads to be carried.

Les Avions-Automobiles. *Aéro Club de France, Revue*, No. 7-8, July-August, 1949, pp. 149–153, illus. Specifications of 7 roadable aircraft.

Évolution Aérodynamique d'un Projet d'Avion Biréacteur. M. Maxime Robin. *Technique et Science Aéronautiques*, No. 3, 1949, pp. 165–185, illus.

Air-Ferry Pantechnicons; An Operator's Suggestion for a Short-Range, High-Capacity "Box-Car" Freighter. Harold Seabrook-Smith. *Flight*, Vol. 57, No. 2151, March 16, 1950, pp. 334–337, illus.

What Is Actual Value of Service Testing? *Aviation Week*, Vol. 52, No. 13, March 27, 1950, pp. 21, 22, 24, illus.

AIRPLANE DESCRIPTIONS

Turbine Engines and Aircraft of the U.S.A.; American Turbine-Powered Aircraft. Roy Cross. *Aeronautics*, Vol. 22, No. 4, March, 1950, pp. 29–40, illus. With tables of principal specifications of military and research aircraft.

British Aircraft for All Duties. *Aeronautics*, Special Trilingual Edition, 1950, pp. 30–41, illus. Specifications of 23 aircraft.

Night Fighter Development. *de Havilland Gazette*, No. 55, February, 1950, pp. 5–7, illus.

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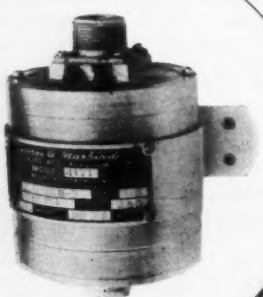

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The Home-Built Aircraft; Its History at Home and Abroad. A. R. Weyl. *Flight*, Vol. 57, No. 2149, March 2, 1950, pp. 298-300.

Le 18e Salon International de l'Aéronautique; Avions, Hélicoptères, Planeurs. *Aéro Club de France, Revue*, No. 3-4, March-April, 1949, pp. 36–93, illus.

Aerei e Motori Italiani; Riepilogo de Caratteristiche. *Alata* (Milan), Vol. 5, No. 5, May, 1949, pp. 29, 31, 33, 35, illus.

Aerocar Roadable Aircraft. *The Aeroplane*, Vol. 78, No. 2022, March 10, 1950, p. 285, illus.

Alaparma 65 Baldo Personal Airplane, Italy. *L'Ala* (Rome), Vol. 5, No. 7, April 1, 1949, p. 8, illus.

Ambrosini S. 1001 Grifo 5-Place Transport, Italy. *Alata* (Milan), Vol. 5, No. 6, June 1, 1949, pp. 20, 21, illus.

Ambrosini S. 1002 Trasimenus Personal Airplane, Italy. *L'Ala* (Rome), Vol. 5, No. 11, June 1, 1949, p. 7, illus.

Auster Autocar Personal Airplane. *Flight*, Vol. 57, No. 2150, March 9, 1950, pp. 304–306, illus.

Bellanca 190 Cruisemaster Personal Airplane. *Shell Aviation News*, No. 139, January, 1950, p. 21, illus.

Boulton Paul Balliol 2 Advanced Trainer. *Flight*, Vol. 57, No. 2148, February 23, 1950, pp. 246–248, illus.

Blackburn-General Universal Freighter. *Flight*, Vol. 57, No. 2152, March 23, 1950, pp. 372–378, cutaway drawing.

Breda 308 Zappata Transport, Italy. *Alata* (Milan), Vol. 5, No. 5, May, 1949, pp. 25–28, illus.

Bristol 167 Brabazon Transport. *Aeronautics*, Special Trilingual Edition, 1950, pp. 42–47, illus.

Caproni Ca. 193 5-Place Pusher Transport, Italy. *Alata* (Milan), Vol. 6, No. 2, February, 1950, pp. 13–16, illus. *Interauto* (Milan), Vol. 7, No. 7, July, 1949, pp. 35, 36, illus.

Chapeau-Blanchet Aero 10/11, 20, 30, Personal Airplanes, France. *Les Ailes* (Paris), Vol. 30, No. 1260, March 25, 1950, pp. 8, 9, illus.

Chrislea Skyjeep Personal Airplane. *Aero Digest*, Vol. 60, No. 3, March, 1950, pp. 24, 127, 128, illus.

C.V.V. Preti P.110 Transport, Italy. *L'Ala* (Rome), Vol. 5, No. 4, February 15, 1949, p. 3, illus.

de Havilland D.H. 106 Comet Turbojet Transport. *de Havilland Gazette*, No. 55, February, 1950, pp. 9–11, illus.

de Havilland 114 Heron Transport. *The Aeroplane*, Vol. 78, No. 2019, February 17, 1950, p. 186, illus. *Flight*, Vol. 57, No. 2147, February 16, 1950, pp. 233–235, illus. *The Log*, Vol. 10, No. 3, March, 1950, pp. 64, 65. *Modern Transport*, Vol. 63, No. 1615, March 11, 1950, p. 10.

de Havilland Sea Vampire Mk. 20 Naval Jet Fighter. *Aeronautics*, Special Trilingual Edition, 1950, pp. 48–51, illus.

de Havilland (Canada) D.H.C.-2 Beaver Transport. *The Aeroplane*, Vol. 78, Nos. 2021, 2023, March 3, 17, 1950, pp. 258–263; 316–319, cutaway drawing.

Douglas DC-6A Liftmaster Cargo Transport. *Douglas Service*, Vol. 8, No. 1, January-February, 1950, pp. 1–4.

Douglas C-124 Globemaster II Transport. *Shell Aviation News*, No. 139, January, 1950, p. 11, illus.

Emigh Trojan A-2 Lightplane Trainer. *Air Trails*, Vol. 34, No. 1, April, 1950, pp. 28, 29, 80, 81, 83, illus.

English Electric Canberra Turbojet Bomber. *Aeronautics*, Special Trilingual Edition, 1950, pp. 56, 57, illus.

Fairchild V-119 Packet Troop Transport. *The Pegasus*, Vol. 15, No. 3, March, 1950, pp. 1–4, illus.

Fiat G.212 Transport, Italy. *L'Ala* (Rome), Vols. 4, 5, Nos. 24, 1, December 15, 1948, January 1, 1949, pp. 8–10, 17; 6, 7; illus.

G.C.A. 1 Pedro Personal Airplane, Italy. *L'Ala* (Rome), Vol. 5, No. 2, January 15, 1949, p. 1, illus.

Handley Page Hermes IV Transport. *Aeronautics*, Special Trilingual Edition, 1950, pp. 64–67, 70, 72–74, illus. *Flight*, Vol. 57, No. 2149, March 2, 1950, pp. 285–289, illus.

Handley Page Hermes V Turboprop Transport. *Handley Page Bulletin*, Vol. 16, No. 170, January, 1950, pp. 4–6, illus.

Handley Page Marathon II Turboprop Transport. *Handley Page Bulletin*, Vol. 16, No. 170, January, 1950, pp. 11–13, illus.

Hawker P. 1052 Turbojet Fighter. *Aeronautics*, Special Trilingual Edition, 1950, pp. 52–55, illus.

Hawker Sea Fury Mk. 20 Naval Trainer. *Aeronautics*, Special Trilingual Edition, 1950, pp. 60–63, illus.

Helio Helioplane Personal Airplane. *Flying*, Vol. 46, No. 4, April, 1950, pp. 14, 15, 60, illus.

Huarte-Mendicoa CASA-201 Alcotan Transport, Spain. *Avión* (Madrid), Vol. 4, No. 37, March, 1949, pp. 110–113, illus.

Hurel-Dubois H-D 10 Personal Airplane, France. *Aéro Club de France, Revue*, No. 5, May, 1949, pp. 114, 115, illus.

Leduc R.L. 16 Personal Airplane, France. *Aéro Club de France, Revue*, No. 6, June, 1949, pp. 134, 135, illus.

Leduc 0.10 Ramjet Research Airplane, France. *Aéro Club de France, Revue*, No. 1, January, 1950, pp. 8–12, illus.

Macchi MB-308 Seaplane, Italy. *L'Ala* (Rome), Vol. 5, No. 6, March 15, 1949, p. 3, illus.

M.A.T.R.A. R-13 Jet Research Airplane, France. *Aéro Club de France, Revue*, No. 3, March, 1950, pp. 43–45, illus.

McDonnell F2H Banshee Naval Jet Fighter. *Aviation Operations*, Vol. 13, No. 2, February, 1950, pp. 29, 54, 55, illus.

Millet-Lagarde ML-10 Biplane Pusher Personal Airplane, France. *The Aeroplane*, Vol. 78, No. 2021, March 3, 1950, p. 257, illus.

Morane-Saulnier M.S. 700 4-Place Transport, France. *Aéro Club de France, Revue*, No. 2, February, 1949, pp. 26, 27, illus.

North American B-25-J (Modified) Trainer. *Aviation Week*, Vol. 52, No. 13, March 27, 1950, p. 15, illus.

North American EF-86A Sabre Turbojet Fighter. *Aviation Week*, Vol. 52, No. 12, March 20, 1950, pp. 20–22, illus.

Republic F-84E Thunderjet Fighter Bomber. *Aviation Operations*, Vol. 13, No. 3, March, 1949, pp. 24, 25, 68, 69, illus.

S.C.A. Béarn GY-20 Minicab Personal Airplane, France. *Aéro Club de France, Revue*, No. 7-8, July-August, 1949, p. 165, illus.

Short S.A. 6 Sealand Amphibian Transport (Aircraft Engineering Reference Sheet, VI). *Aircraft Engineering*, Vol. 22, No. 252, February, 1950, pp. 49–52, cutaway drawings.

SIAI-Marchetti SM.95 Transport, Italy. *Velocidade* (Sao Pãulo, Brazil), Vol. 10, No. 9, September, 1948, pp. 25, 26, illus.

S.N.C.A.C. N.C. 853 Leger Personal Airplane, France. *Aéro Club de France, Revue*, No. 1, January, 1949, p. 5, illus.

Starck A.S. 80 Personal Airplane, France. *Les Ailes* (Paris), Vol. 30, No. 1259, March 18, 1950, pp. 8, 9, illus.

T.H.K. Legers Transport, Turkey. *Les Ailes* (Paris), Vol. 30, No. 1250, January 14, 1950, p. 8, illus.

Vickers-Armstrongs 510 Supermarine Turbojet Fighter. *Flight*, Vol. 57, No. 2149, March 2, 1950, pp. 290–294, cutaway drawing.

Vickers-Armstrongs Viscount Turbojet Transport. *Aeronautics*, Special Trilingual Editon, 1950, pp. 58, 59, illus.

Yak-15 Fighter, U.S.S.R. *Aero Digest*, Vol. 60, No. 3, March, 1950, pp. 34, 134, 135, illus.

BODY GROUP

Les Avions a Cabines Étanches. C. Heubes. *La Recherche Aéronautique*, No. 5, September-October, 1948, pp. 35–52, illus.

LANDING GEAR

Design Trends: Landing Gears. *Aeronautical Engineering Review*, Vol. 9, No. 3, March, 1950, pp. 46, 47, illus. Boeing Stratocruiser main gear and actuating mechanism.

Caterpillar Tracks. O. F. Maclaren. *Aeronautics*, Special Trilingual Edition, 1950, pp. 93, 94, 96–98, illus.

Wheel-Skis Increase Airplane Utility. *Aviation Operations*, Vol. 13, No. 2, February, 1950, p. 36, illus.

Airports & Airways (39)

The Delayed Invention. Willy Ley. *Technology Review*, Vol. 52, No. 4, February, 1950, pp. 207–210, 230, illus.

A review of the designs for seadromes or floating islands to facilitate transoceanic flying.

Planning the Air Freight Terminal. I. L. R. Hackney. *Air Transportation*, Vol. 16, No. 3, March, 1950, pp. 10, 11, 22–24, illus.

Airphoto Patterns of Soils of the Western United States; As Applicable to Airport Engineering. Robert E. Frost and K. B. Woods. *U.S., Civil Aeronautics Administration, Technical Development Report No. 85*, August, 1948. 76 pp., illus.

The Stake on the Scheduled Airlines in Sound Airport Development. James C. Buckley. *Journal of Air Law and Commerce*, Vol. 17, No. 1, Winter, 1950, pp. 22-31.

Equipos Contra Incendios y de Salvamento en los Aerodromos. Leopoldo Tacchi. *Revista de la Fuerza Aerea* (Chile), Vol. 9, No. 33, April–June, 1949, pp. 26–29.

The Laying of Airfield Runways; A Description of the Pouring of the Concrete at the Saab's Airfield. *Saab Sonics*, No. 9, January–March, 1950, pp. 11–13, illus.

Kindly Lights. *Aeronautics*, Special Trilingual Edition, 1950, pp. 82, 83, 86, illus. Landing-light systems at London Airport.

Air Transportation (41)

International Ownership and Operation of World Air Transport Services; Summary and Background Material. John C. Cooper. *Princeton University, Institute for Advanced Study, Edwin G. Baetjer II Memorial Conference, 2nd*, October 23, 24, 1948. 174 pp.

Air Cargo Economics. John P. Carter. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 78–96, illus.

Comparison of volume and rates for air express and air freight with figures for surface transportation, and a forecast of the character, volume, and earnings prospects for future air traffic under existing and probable Government regulations, rate structures, and subsidy policies.

The Freight Forwarder and the Development of Air Freight. John C. Emery. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 29–36.

The Development of International Air Freight. Raymond A. Norden. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 59–68.

Outline of the requirements for a successful transocean freight carrier enterprise, which includes the experience and ability required of the personnel, operating practices, necessary equipment, and prospects for holding a place in world commerce and national defense.

The Impact of Air Freight on Surface Transportation. Robert S. Henry. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 47–58.

Although the volume of air-freight movements increased 170 per cent in the period 1946 through 1948, the total was only a small fraction of the volume of surface movements. Air-freight revenues were far below the costs of operation. Unless some method of cost reduction is found, it is unlikely that air freight will seriously affect the volume or rates for surface transportation.

Introduzione allo Studio del Costo di Esercizio del Aereo. Alfonso Cucci. *Revista Aeronautica*, Vol. 25, No. 3, March, 1949, pp. 177–189.

Air Transport in Germany. *Modern Transport*, Vol. 63, No. 1615, March 11, 1950, p. 11, illus.

Formula for International Air Freight; Bulk + Flexibility + Speed. Richard E. Stockwell. *Aviation Operations*, Vol. 13, No. 2, February, 1950, pp. 21, 22, 48, illus.

Crop Dusting in the West. James Joseph. *Aviation Operations*, Vol. 13, No. 2, February, 1950, pp. 27, 64, 65, illus.

Aviation Medicine (19)

Eye Movements of Aircraft Pilots During Instrument-Landing Approaches. Paul M. Fitts, Richard E. Jones, and John L. Milton. *Aeronautical Engineering Review*, Vol. 9, No. 2, February, 1950, pp. 24–29, illus. 1 reference.

Magnitude of Forces Which May Be Applied by the Prone Pilot to Aircraft Control Devices. II—Two-Dimensional Hand Controls. III—Foot Controls. C. W. Brown, E. E. Ghiselli, and others. *U.S., Air Force, Technical Report Nos. 5954, 5955*, February, 1950. 29; 10 pp., illus. 3 references.

Eye Fixations of Aircraft Pilots. II—Frequency, Duration, and Sequence of Fixations when Flying the USAF Instrument Low Approach System (ILAS). III—Frequency, Duration, and Sequence Fixations when Flying Air Force Ground-Controlled Approach System (GCA). Paul M. Fitts, Richard E. Jones, and John L. Milton. *U.S., Air Force, Technical Report Nos. 5839, 5967*, October, 1949, February, 1950. 20; 22 pp., illus. 7 references.

Study of Exterior Lighting for Navy Airplanes. V—The Illumination of Lights on the Trailing Edge of Wings for Low Level Illumination of Aircraft. VI—Night Flight Tests of Experimental

Exterior Lighting Systems on Military Aircraft. Irene C. Blasdel. *U.S., Naval Air Experimental Station, Aeronautical Medical Equipment Laboratory, Philadelphia, Report TED No. NAM 31333,* May 31, June 1, 1949. 10; 39 pp., illus. 16 references.

Effect of Intermittent Positive Pressure Breathing on Respiratory Gas Exchange. Hurley L. Motley, Leonard P. Lang, and Burgess Gordon. *Journal of Aviation Medicine,* Vol. 21, No. 1, February, 1950, pp. 14–27, illus. 19 references.

Comparison of the Protective Value of an Antiblackout Suit on Subjects in an Airplane and on the Mayo Centrifuge. Edward H. Lambert. *Journal of Aviation Medicine,* Vol. 21, No. 1, February, 1950, pp. 28–37, illus. 13 references.

Tests of the G-4 (Z-1) antiblackout suit performed on 13 subjects in an airplane and on the Mayo centrifuge showed that the operation and effectiveness of the suit were essentially the same under comparable conditions, with *g* tolerance rates averaging only 0.1*g* higher in the airplane for the visual symptoms, blood content of the ear, ear-pulse amplitude, and ear-pulse rate.

Electromyographic Study of the Effects of Various Headward Accelerative Forces upon the Pilot's Ability to Perform Standardized Pulls on an Aircraft Control Stick. J. Gordon Wells and Laurence E. Morehouse. *Journal of Aviation Medicine,* Vol. 21, No. 1, February, 1950, pp. 48–54, illus.

The Effect of Ambient and Body Temperatures upon Reaction Time. George Forlano. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest,* Vol. 15, No. 4, April 1, 1950, pp. 18–26, illus. 16 references.

The Use of Drugs in Aviation Medicine. Fred W. Oberst and Helen M. Ely. *The Military Surgeon,* Vol. 106, No. 3, March, 1950, pp. 192–197. 22 references.

A Study of the Requirements for Letters, Numbers and Markings to Be Used on Trans-Illuminated Aircraft Control Panels. II—A Survey of Pilot Preferences for Markings for Rheostat Controls. Fred R. Brown and Edward A. Lowery. *U.S., Naval Air Experimental Station, Aeronautical Medical Equipment Laboratory, Philadelphia, Report TED No. NAM EL-609,* February 1, 1950. 13 pp., illus. 3 references.

Instrument Lighting-Investigations of Ultra-Violet Reflections. II—Measurements of Ultra-Violet Energy in Aircraft Cockpits Equipped with Fluorescent Instrument Lighting. John Lazo and Fred R. Brown. *U.S., Naval Air Experimental Station, Aeronautical Medical Equipment Laboratory, Philadelphia, Report TED No. NAM 31334,* February 1, 1950. 30 pp., illus.

Visual Problems in Designing Improved Indirect Lighting for Aircraft Cockpits. Fred R. Brown and John R. Poppen. *Journal of Aviation Medicine,* Vol. 21, No. 1, February, 1950, pp. 3–13, 47, illus. 5 references.

Evaluation of direct and indirect lighting systems for instrument panels and control consoles, which shows the advantages of indirect red light with added floodlighting for instruments, and of edge-lighted plastic plates for control panels.

A Study of the Applicability of Indirect Illumination Methods to Individual Aircraft Instruments. Fred R. Brown. *U.S., Naval Air Experimental Station, Aeronautical Medical Equipment Laboratory, Philadelphia, Report TED No. NAM EL-318,* May 4, 1949. 15 pp., illus. 12 references.

"*G*" e i Suoi Multipli. Carlo Alippi. *L'Aerotecnica,* Vol. 28, No. 4, August 15, 1948, pp. 179–184, illus. 9 references.

Sudden Spontaneous Accidents to the Brain in Healthy Young Adults. Rudolph Jaeger. *Journal of Aviation Medicine,* Vol. 21, No. 1, February, 1950, pp. 55–57.

Brief discussion of various brain disorders that may disable a pilot during flight and cause an accident.

Decisions in Eye Injuries. Carroll R. Mullen. *Journal of Aviation Medicine,* Vol. 21, No. 1, February, 1950, pp. 58–61, 75. 3 references.

Educational Program for Flight Nurses. Verena Zeller. *The Military Surgeon,* Vol. 106, No. 3, March, 1950, pp. 217, 218.

Initial Studies of the Effect of Laboratory-Produced Air Blast on Animals. Benedict Cassen, Lawrence Curtis, and Katherine Kistler. *Journal of Aviation Medicine,* Vol. 21, No. 1, February, 1950, pp. 38–47, illus. 9 references.

Deceleration Studies Provide Air Crash Data. Gilbert C. Close. *Aviation Operations,* Vol. 13, No. 2, February, 1950, pp. 41, 63, 64, illus.

Factores Humanos en los Accidentes de Aviación. Raúl Yazigi Jáuregui. *Revista de la Fuerza Area* (Chile), Vol. 9, No. 33, April–June, 1949, pp. 11–25.

Comfortization (23)

Designing for Comfort in Aircraft Seats. Stanley Lippert. *Aeronautical Engineering Review,* Vol. 9, No. 2, February, 1950, pp. 39–41, illus.

Electronics (3)

Radio Equipment on the (de Havilland) Comet. *Electrical Communication,* Vol. 27, No. 1, March, 1950, p. 6, illus.

Problems of Frequency Allocation. *Aviation Week,* Vol. 52, No. 11, March 13, 1950, pp. 32–34, 36.

The Linear Theory of Fluctuations Arising from Diffusional Mechanisms; An Attempt at a Theory of Contact Noise. J. M. Richardson. *Bell System Technical Journal,* Vol. 29, No. 1, January, 1950, pp. 117–141. 16 references.

Communication in the Presence of Noise; Probability of Error for Two Encoding Schemes. S. O. Rice. *Bell System Technical Journal,* Vol. 29, No. 1, January, 1950, pp. 60–93, illus. 8 references.

Shunt-Excited Flat-Plate Antennas with Applications to Aircraft Structures. J. V. N. Granger. *Institute of Radio Engineers, Proceedings,* Vol. 38, No. 3, March, 1950, pp. 280–287, illus. 9 references.

Antennes Diélectriques Omni-Azimutales pour Ondes Ultra-Courtes. C. Ducot. *La Recherche Aéronautique,* No. 9, May-June, 1949, pp. 33–42, illus. 5 references.

Les Régulateurs de Tension a Faible Puissance. M. Delattre. *France, Office National d'Études et de Recherches Aéronautiques, Publication No. 18,* 1948. 79 pp., illus. 51 references.

Régulateur de Tension Électrique (Système Vernotte-Bory) a Compensation Automatique. Charles Bory. *France, Ministère de l'Air, Publications Scientifiques et Techniques, Note Technique No. 30,* 1948. 27 pp., illus. Service de Documentation et d'Information Technique de l'Aéronautique, Paris. 130 Fr.

Oscillateurs a Résistances et Capacités. J. Zakheim. *La Recherche Aéronautique,* No. 9, May-June, 1949, pp. 11–18, illus. 8 references.

Oscillateurs Electroniques pour Systèmes de Télécommande et de Télémesure. Gérard Lehmann. *La Recherche Aéronautique,* No. 9, May-June, 1949, pp. 9, 10.

Effet Remarquable dans le Diagramme Vertical d'Un Emmettuer; Ses Rapports avec un Curieux Phénomene d'Evanouissement en Vol. G. Eckart. *La Recherche Aéronautique,* No. 6, November-December, 1948, pp. 43–46, illus. 10 references.

Sur la Propagation des Ondes Électromagnétiques "Planes" dans un Milieu Stratifié. G. Eckart. *La Recherche Aéronautique,* No. 8, March-April, 1949, pp. 33–35, illus. 1 reference.

"Radiolympia" in Miniature; The Wide Range of Redifon Products Reviewed. *Airports & Air Transportation,* Vol. 5, No. 81, March, 1950, pp. 17–22, illus.

Engineering Practices (49)

Drawing Sphere for Analysis of Flight Test Results. S. Wynia and L. R. Lucassen. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Report No. V. 1543,* 1949. 3 pp., illus. 6 references.

A steel sphere of 55 cm. diameter is mounted on a suitable support and used, with an octant gage and a great-circle gage, to obtain approximate solutions of trigonometric problems arising in the evaluation of flight-test results. The devices facilitate the translation of aircraft-instrument readings indicating attitude, slide slip, roll, and bank and produce, in a matter of 10 minutes, information that would require about one hour to compute from formulas.

Linear Equation Solvers. F. J. Murray. *Quarterly of Applied Mathematics,* Vol. 7, No. 3, October, 1949, pp. 263–274. 3 references.

Equipment

Manufacturers of Aeronautical Accessories. *Aeronautics,* Special Trilingual Edition, 1950, p. 81. Directory of 61 British manufacturers.

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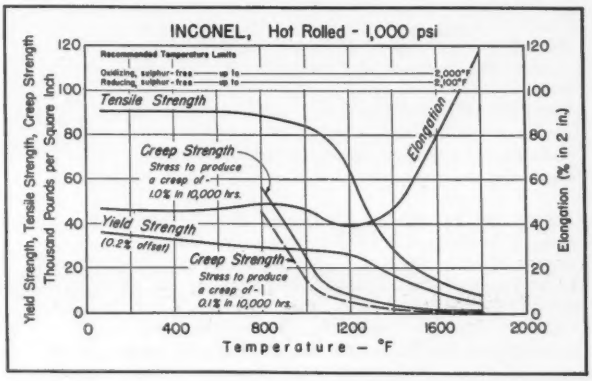
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Elongation (% in 2 in.)
Recommended Temperature Limits
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Reducing, sulphur-free — up to 2,100°F
Tensile Strength
Elongation
Creep Strength
Stress to produce a creep of 1.0% in 10,000 hrs.
Yield Strength
(0.2% offset)
Creep Strength
Stress to produce a creep of 0.1% in 10,000 hrs.
Temperature — °F

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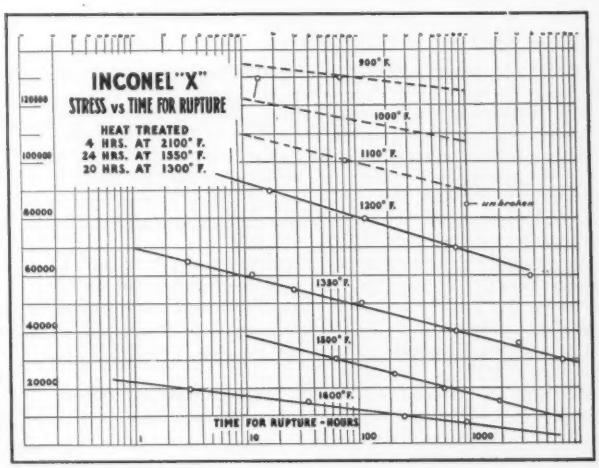

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ELECTRICAL (16)

Lamps for Aircraft Lighting. *Aero Digest*, Vol. 60, No. 3, March, 1950, p. 28. Lamps recommended by the Illuminating Engineers Society and the Society of Automotive Engineers.

HYDRAULIC & PNEUMATIC (20)

Aircraft Hydraulics. I—The Basic Hydraulic System. II—The Development of the Modern Electro-Hydraulic System. J. Stuart Backhouse. *The Technical Instructor*, Vol. 5, Nos. 1, 2, January, February, 1950, pp. 14–18; 16, 17, 19; illus.

A simplified explanation of the principles of hydrostatics and hydrodynamics and their application to the operation of aircraft control mechanisms.

Super DC-3 Hydraulic System. Fred O. Hosterman. *Applied Hydraulics*, Vol. 3, No. 2, March, 1950, pp. 26, 27, illus.

Basic Theory and Application of Hydraulic Systems. James T. Clark. *Applied Hydraulics*, Vol. 3, No. 2, March, 1950, pp. 28, 39.

Theory and Practice in the Design of Hydraulic Seals. I. II. R. O. Isenbarger. *Applied Hydraulics*, Vol. 3, Nos. 1, 2, February, March, 1950, pp. 14–16, 20, 40; 22–24; illus.

Reduction of Hydraulic Noise and Vibration. I. II. G. W. Louthan. *Applied Hydraulics*, Vols. 2, 3, Nos. 12, 1, January, February, 1950, pp. 20–22, 28, 30; 23, 24, 26, 44; illus.

A Completely Nonflammable Aircraft Hydraulic Fluid. B. B. Farrington, N. W. Furby, and J. M. Stokely. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint.* 8 pp., illus. 4 references.

Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

Aircraft De-Icing Trials. *The Engineer*, Vol. 189, No. 4907, February 10, 1950, pp. 185, 186, illus.

The leading edges of the wings, tailplane, and fin of the Vickers Viscount transport were provided with thermal ducts taking heat from the jet pipes of the Rolls-Royce Dart engines. Because it has a centrifugal compressor, the engine is not equipped with a deicing system as such, but the intakes are heated to avoid excessive fuel consumption caused by ice-clogged air passages. The propellers are heated electrically.

Shedding Ice. *Airports & Air Transportation*, Vol. 5, No. 81, March, 1950, pp. 23, 24, illus. Hot-gas thermal duct method of ice prevention and removal used on the Vickers-Armstrongs Viscount jet transport.

De-Icing the Viscount. *The Aeroplane*, Vol. 78, No. 2019, February 17, 1950, p. 190, illus.

De-Icing the Viscount; Hot-Gas Thermal Method. *Flight*, Vol. 57, No. 2147, February 16, 1950, pp. 236, 237, illus.

NOISE REDUCTION

A Method for the Calculation of the Noise Spectrum of Aircraft. M. Kobrynski. (*La Recherche Aéronautique*, No. 11, September-October, 1949, pp. 37–45.) *The Engineers' Digest*, Vol. 11, No. 2, February, 1950, pp. 38–43, illus. 3 references. (Extended summary of a paper.)

Les Principes Généraux de l'Insonorisation des Avions. P. Lienard and M. Kobrynski. *La Recherche Aéronautique*, No. 6, November-December, 1948, pp. 57–64, illus. 4 references.

WEATHER HAZARDS

La Dissipation des Brouillards et la Destruction des Nauges Givrants. Lucien Demon. *La Recherche Aéronautique*, No. 6, November-December, 1948, pp. 23–34, illus. 12 references.

Flight Safety & Rescue (15)

Determination of the Air Speed Required to Control Landing Gear Fires. Lyle E. Tarbell and Burnett C. Street. *U.S., Civil Aeronautics Administration, Technical Development Report No. 100*, December, 1949. 8 pp., illus.

A mock-up of a landing-gear strut and wheel was subjected to fire caused by burning hydraulic fluid under air flows ranging up to 140 m.p.h. The air blast from the propeller, when turning at slow speed, caused the flames to be blown backward from the landing gear and tire, but not with sufficient force to prevent damage to the adjoining structure. As the propeller speed increased to approximately 70 m.p.h. air speed, the flame spread was brought under control and higher speeds reduced the flame cross section and elongated the ball of flame. Even at 140 m.p.h. it was difficult to dislodge the flame, but higher air speeds would probably extinguish them. The burning tire, in a 15 m.p.h. wind, exploded in 2 min., $16^1/_2$ seconds without structural damage, but under certain conditions the explosion might have caused injury to near-by personnel.

Airplane Crash Fire Fighting; A Manual on Operational Practices in Rescue and Extinguishment. *U.S. Navy, Aviation Training Division, Publication No. NA 00-80R-14*, February, 1946. 106 pp., illus.

The Fire Danger in Aircraft; An Examination of Methods of Prevention and Extinction, with References to the Various Regulations. R. H. Selby-Hele. *Aircraft Engineering*, Vol. 22, No. 251, January, 1950, pp. 2–7, 11, illus. 9 references.

Fire Out—By Design; A Review of the Civil Aeronautics Administration Fire Test Program at Indianapolis. Harvey L. Hansberry. *National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletin No. 46*, March, 1950. 8 pp.

Crash Safety Can Be Engineered. *Aviation Week*, Vol. 52, No. 11, March 13, 1950, pp. 28–30, illus.

Some Notes on Accident Investigation. Vernon Brown. *Guild of Air Pilots and Air Navigators (London), Journal*, Vol 10, No. 1, February, 1950, pp. 8–10.

Fuels & Lubricants (12)

The Hydrodynamical Theory of Film Lubrication. W. F. Cope. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 197, No. 1049, June 7, 1949, pp. 201–217, illus. 13 references.

Equations of film lubrication which are derived from the general equations of hydrodynamics, assuming that only steady motion takes place between two surfaces that are close together, nearly parallel, and in relative motion, show the relative magnitude of the various terms under typical conditions measured in a bearing, to be of such unequal orders that the inertia term in the momentum equation and the dialation and conductivity terms in the energy equation can be neglected. Film lubrication is possible only if either the distance between the surfaces decreases in the direction of motion (the geometric wedge), or the density of the fluid decreases in the same direction (the thermal wedge). When compared on a basis of equal film thickness and equal decrease, both films are approximately equal. Although with the geometric wedge a much greater decrease and, therefore, load-carrying capacity is possible, the thermal wedge, because of its simpler mechanical construction, should be able to run with a thinner film.

A Contribution to the Hydrodynamics of Lubrication. Gregory H. Wannier. *Quarterly of Applied Mathematics*, Vol. 8, No. 1, April, 1950, pp. 1–32, illus. 8 references.

The Experimental Testing of Solid Chemical Rocket Propellants. Alfred J. Zaehringer. *Rocketscience*, Vol. 4, No. 1, March, 1950, pp. 11–16, illus. 5 references.

Problemi e Aspetti Attuali de Combustibili Avio. Virgilio Ceccarini. *L'Aerotecnica*, Vol. 29. No. 4, August 15, 1949, pp. 199–214, illus. 26 references.

Aplicaciones Dinámicas de los Propulsores Químicos y su Desarrollo en el Campo de la Técnica Aeronáutica. Aldo Cresta. *Avia* (Argentina), Vol. 16, No. 168, March, 1949, pp. 53–60, illus.

Il Tetranitrometano e la sua Preparazione Tecnica. R. M. Corelli. *L'Aerotecnica*, Vol. 29, No. 5, October 15, 1948, pp. 264–271, illus.

Metodo Rapido per la Determinazione del Piombo-Tetraetile Nei Carburanti. E. Cianetti, C. Marangoni, and E. G. Pampanelli. *L'Aerotecnica*, Vol. 28, No. 6, December 15, 1948, pp. 321–324, 330.

Dosage du Plomb Tétraéthyle dans les Combustibles. Raymond Lautié and Madeline Sarrat. *La Recherche Aéronautique*, No. 9, May-June, 1949, pp. 25–28. 12 references.

Correlation of Effects of Fuel-Air Ratio, Compression Ratio, and Inlet-Air Temperature on Knock Limits of Aviation Fuels. Leonard K. Tower and Henry E. Alquist. *U.S., N.A.C.A., Technical Note No. 2066*, April, 1950. 57 pp., illus. 5 references.

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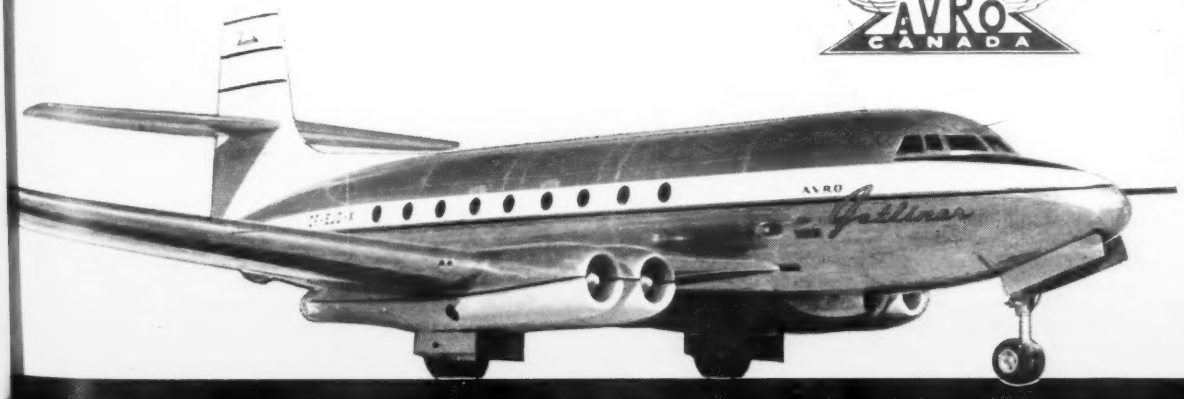

Microdetermination of Knock Characteristics of Motor Fuels. Julian Alexander, Jr., and Carl Pfeiffer. *Analytical Chemistry*, Vol. 22, No. 3, March, 1950, pp. 476–480, illus. 3 references.

Gliders (35)

Finding the Best Speed for Cross-Country Soaring. Kalle Temmes. *Soaring*, Vol. 14, Nos. 1–2, January–February, 1950, pp. 6–8, illus.

Soaring Hope (Loudon Sailplane). *Aircraft and Airport*, Vol. 12, No. 3, March, 1950, pp. 7, 8, illus.

Flat Top Laister-Kauffman TG 4-A. Charles Alliston. *Soaring*, Vol. 14, Nos. 1–2, January–February, 1950, pp. 13, 14, illus.

Flight Characteristics of the Flat Top TG-4A. August Raspet. *Soaring*, Vol. 14, Nos. 1–2, January–February, 1950, pp. 9–11, illus.

Guided Missiles (1)

The Effect of Variation of Mass on the Dynamic Stability of Jet-Propelled Missiles. M. V. Barton. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, pp. 197–203, illus. 6 references.

Instruments (9)

Instrumentation for Exterior Ballistic Research in Rocketry. L. M. Biberman. *Instruments*, Vol. 23, No. 2, February, 1950, pp. 184–186, illus.

A system of illumination was developed using reflex-reflector material similar to that employed in "Scotchlite" reflecting highway markers. In this silhouette technique the reflector is illuminated in such a way that the light intensity on the screen varies inversely with the reflective characteristics of the reflector and the transmission characteristics of the camera lens. The result is a background brilliantly illuminated periodically for durations of approximately one microsecond, and the projectile passing before the reflector is photographed in silhouette, appearing as a sharp image within its anticipated zone of dispersion. A projectile edge can be determined to within three to four microns on the photographic plate, which is approximately twice the anticipated degree of precision for such a system.

Instrumentation Requirements for Airline Aircraft. R. D. Kelley. *Instruments*, Vol. 23, No. 2, February, 1950, pp. 136–139, illus.

A review of the development of instrumentation for transport aircraft predicts more extensive use of recording instruments to provide more complete and accurate records than the logs maintained by flight crews.

An Investigation of the Possible Use of the Glow Discharge as a Means for Measuring Air Flow Characteristics. F. D. Werner. *Review of Scientific Instruments*, Vol. 21, No. 1, January, 1950, pp. 61–68, illus. 3 references.

Experimental investigation of the glow discharge in air at atmospheric pressure from a point of fine platinum wire showed that the glow current is markedly sensitive to pressure but is only slightly sensitive to humidity and ordinary temperature variations. Such a measuring device might be an improvement over conventional pressure-measuring instruments because of the small size of its sensitive portions, and its response to high-frequency variations.

M.I.T. Calculator "Flight Tests" Theoretical Aircraft. *Aviation Operations*, Vol. 13, No. 3, March, 1950, p. 42, illus.

Transient Analysis of a Speed Regulator Servomechanism. Andrew Vazsonyi. *U.S., Naval Ordnance Test Station, Inyokern, Calif., Pasadena Annex, Report No. 1147 (NOTS 202)*, April 27, 1949. 42 pp., illus. 1 reference.

A typical speed regulator has been analyzed by the classical differential equation method in order to show the effect of linear time lags, derivative circuit, integral circuit, and errors in these circuits. The method employs a chart that gives the performance of the third-order linear differential equation and uses the method of successive approximations to determine the roots of higher order equations. The nature of the solutions has been confirmed by transient response curves obtained from an electric analog computer.

Transient Analysis of an Angular-Position Servomechanism. Andrew Vazsonyi. *U.S., Naval Ordnance Test Station, Inyokern, Calif., Pasadena Annex, Report No. 1149 (NOTS 204)*, May 24, 1949. 23 pp., illus. 2 references.

A variable-voltage angular-position servomechanism is investigated by means of a set of charts that have been drawn up to handle certain fourth-order equations.

A Generalization of Nyquist's Stability Criterion. Andrew Vazsonyi. *U.S., Naval Ordnance Test Station, Inyokern, Calif., Pasadena Annex, Report No. 1148 (NOTS 203)*, April 27, 1949. 14 pp., illus. 2 references.

A more generalized form of the Nyquist theorem which permits a quantitative correlation between the classical and the frequency (steady state) methods of analysis. The generalized Nyquist diagram yields a lower limit to the damping ratios and thus permits the evaluation of the stability and the degree of stability of systems that are characterized by ordinary linear differential equations.

How D-C Synchros Work. Robert A. Gerg and Charles R. Mikolic. *Product Engineering*, Vol. 21, No. 3, March, 1950, pp. 137–140, illus.

Proven Actuator Now Available. *Aviation Week*, Vol. 52, No. 12, March 20, 1950, p. 17, illus. Lear, Inc., Model 118B-3 servo-actuator.

Étude des Servomécanismes. P. Lamy. *Technique et Science Aéronautiques*, No. 3, 1949, pp. 125–130.

Accuracy of Airspeed Measurements and Flight Calibration Procedures. Wilber B. Huston. *U.S., N.A.C.A., Report No. 919*, 1948. 36 pp., illus. 97 references. U.S. Govt. Printing Office, Washington. $0.25.

A Method of Calibrating Airspeed Installations on Airplanes at Transonic and Supersonic Speeds by Use of Temperature Measurements. John A. Zalovcik. *U.S., N.A.C.A., Technical Note No. 2046*, March, 1950. 25 pp., illus. 2 references.

A New Method of Recording Flight Data. Henry Sostman. *Instruments*, Vol. 23, No. 1, January, 1950, pp. 36, 37, illus.

A compact, chart-drawing air-borne recorder translates electrical signals representing air speed, pressure, altitude, acceleration, vibration, pitch, and yaw into graphs that are legible, permanent, unaffected by handling, and resistant to salt water. D'Arsonval galvanometers operating on 28 volts d.c. or 115 volts a.c. activate stylus mechanisms. The sapphire cone of the stylus is heated by an electric coil and traces on Thermaline heat-sensitive chart paper that is treated with a coating of white oxide. The trace appears as a fine black line without developing or any other processing. Up to four charts can be driven at different speeds by an electric motor and gearing to make four simultaneous records.

Long Range Multi-Channel Telemetering System. John T. Mengel. *Instruments*, Vol. 23, No. 1, January, 1950, pp. 70–72, illus.

The Matrix Telemetering System developed by the Naval Research Laboratory utilizes pulse-time modulation to convey data at varying d.c. voltages. An air-borne transmitter in a guided missile at distances up to 500 miles can transmit on 30 channels to a ground recording station.

Télécommande et Téléguidage. J. A. Grégoire. *Aéro Club de France, Revue*, No. 6, June, 1949, pp. 128–133, illus.

Radio-Télémesure pour Engins Aériens. F. Lajeunesse and E. Mattei. *La Recherche Aéronautique*, No. 8, March-April, 1949, pp. 37–41, illus. 3 references.

Vortex Thermometer for Measuring True Air Temperatures and True Air Speeds in Flight. Bernard Vonnegut. *Review of Scientific Instruments*, Vol. 21, No. 2, February, 1950, pp. 136–141, illus. 3 references.

The aerodynamic heating experienced by thermometers exposed from airplanes can be almost eliminated over a wide range of operating conditions by mounting the thermometer in the center of an air vortex created by a simple housing. The method has simplified air-temperature measurements over the operating range of a B-17 airplane and has promise of measuring temperatures in clouds. True air speeds can be measured by the difference between the temperature of the vortex thermometer and a thermometer exposed in the usual manner. Designs and flight data are presented for several vortex thermometers and a simple true air-speed indicator.

A New Method for Surface-Temperature Measurement. Nobuji Sasaki. *Review of Scientific Instruments*, Vol. 21, No. 2, February, 1950, pp. 1–3, figs. 2 references.

The surface temperature of a body can be measured exactly by the use of a thermocouple with a measuring junction adjustable to any temperature. The temperature of the junction, which is

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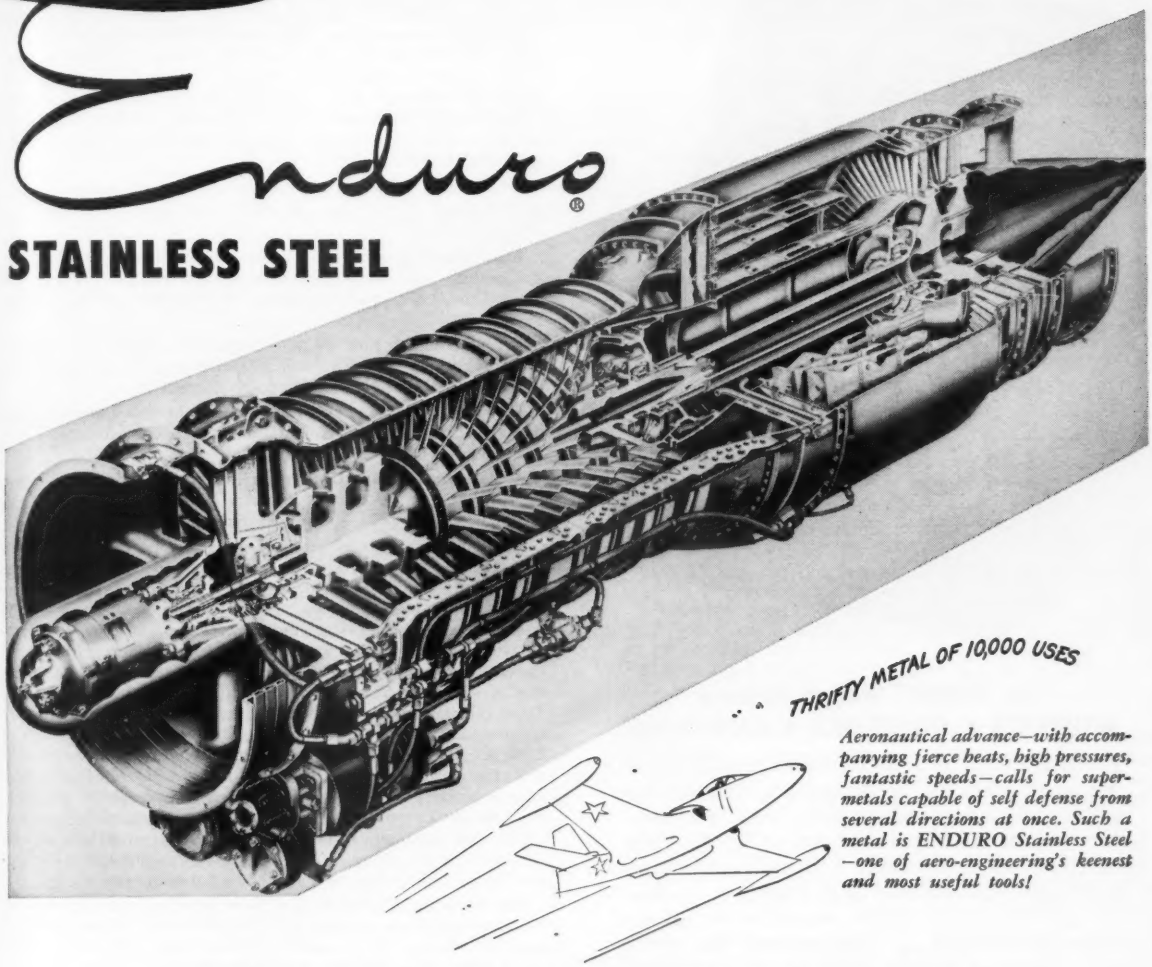

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Dynamic Accuracy in Temperature Measurement. J. G. Ziegler and N. B. Nichols. *Instruments*, Vol. 23, No. 1, January, 1950, pp. 66–69, illus.

Étude des Hygromètres a Baudruches; Peaux de Batteur d'Or. P. Gondet. *Journal Scientifique de la Météorologie*, Vol. 1, No. 2, April–June, 1949, pp. 33–47, illus. 3 references. (English summary.)

Procédé de Mesure de la Vitesse d'un Écoulement d'Air. M. Cambornac. *La Recherche Aéronautique*, No. 5, September-October, 1948, pp. 15, 16, illus.

Mesure de Vitesses Aérodynamiques au Moyen d'une Méthode de Perturbations. M. Tisseau. *La Recherche Aéronautique*, No. 5, September-October, 1948, pp. 17–30, illus.

A Versatile Pneumatic Instrument Based on Critical Flow. W. A. Wildhack. *Review of Scientific Instruments*, Vol. 21, No. 1, January, 1950, pp. 25–30, figs. 7 references.

The device consists basically of two restrictions in series, such as a variable orifice and a nozzle, through one or both of which gas is drawn at sonic throat velocity so that discharge is independent of the downstream pressure. Variations in flow through the first nozzle or orifice, occurring with changes of pressure, temperature, or size, are reflected as changes in absolute pressure at the entrance to the second nozzle, the value of the absolute pressure serving as a measure of the variable causing the change. After calibration, the pressure ratio may be used to measure temperature with a sensitivity of 1°C. or better over a range of 2,000°C. With the same arrangement and constant temperature, the intermediate pressure is a direct measure of mass flow with sensitivity better than 0.1 per cent. For given temperatures the device can be used as a pressure divider, with the intermediate pressures controlled by adjusting the restrictions, or as a pneumatic micrometer. Gas analysis is accomplished by removing one component of the gas flow between nozzles.

The Dynamic Vibrometer, a New Electrical Instrument for Mechanical Measurements. J. Dreyfus-Graf. (*Schweizer Archiv*, Vol. 15, No. 11, November, 1949, pp. 338–343.) *The Engineers' Digest*, Vol. 11, No. 2, February, 1950, pp. 49–52, illus. (Extended summary of a paper.)

Un Extensomètre Enregistreur. Marc Bassiére. *La Recherche Aéronautique*, No. 9, May-June, 1949, pp. 55, 56, illus.

A New Interferometer. E. R. Johnson and J. F. M. Scholes. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 1, No. 4, December, 1948, pp. 464–471, illus., diagrs. 4 references.

The modification of the Mach-Zehender interferometer by collimating the beams after they pass through the dividing plate makes it possible to use a small dividing plate without lessening the wide field covered by the main beam. The design involves the use of two pairs of lenses instead of one. The pair in the auxiliary beam can be of small aperture, and the large lenses in the main beam may be replaced by parabolic mirrors. It is necessary to introduce compensating plates in order to make the optical path lengths equal in the two pairs of lenses.

A Simple Pressure Balance. C. A. Swenson. *Review of Scientific Instruments*, Vol. 21, No. 1, January, 1950, pp. 22–24, diagrs. 1 reference.

A steel piston lap-fitted without precision workmanship into a steel cylinder filled with oil gives pressure measurements with accuracy of 0.05 per cent in the pressure range of 25 to 36 atmospheres.

Design and Use of Piezoelectric Gauges for Measurement of Large Transient Pressures. A. B. Arons and R. H. Cole. *Review of Scientific Instruments*, Vol. 21, No. 1, January, 1950, pp. 31–38, illus., figs. 7 references.

Statement of fundamental design principles, gage construction, reasons for use of tourmaline instead of other crystals, and a simple theoretical analysis of transient response characteristics.

Research in Applied Optics at the National Bureau of Standards. Irvine C. Gardner. *U.S., National Bureau of Standards, Technical Report No. 1432*, March, 1950. 13 pp., illus. 5 references.

Monographe Photoélastique; A Déformation de Paroi pour l'Enregistrement des Variations de Pression dans les Tuyauteries d'Injection de Combustible. Roger Kling and Robert Gilis. *La Recherche Aéronautique*, No. 8, March-April, 1949, pp. 3, 4, illus.

Polarized Light Shows Nature of Plastic Deformation in Monel Metal. *U.S., National Bureau of Standards, Technical Report No. 1433*, March, 1950. 4 pp., illus. 1 reference.

Visual Strain-Recorder; New Airspeed Polygraph Equipment Displays Information During Test. *Aircraft Production*, Vol. 12, No. 138, April, 1950, pp. 131, 132, illus.

Balance G.S. de la Soufflerie de Cannes. A. Beveret and A. de Sievers. *La Recherche Aéronautique*, No. 6, November-December, 1948, pp. 35–41, illus.

Laws & Regulations (44)

Liability Problems of Air Cargo Carriage. Charles S. Rhyne. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 69–77.

Courts have upheld reasonable limitations on liability imposed by air-cargo carriers, and in cases of international transportation, the Warsaw Convention provides clearly defined rules. A uniform law is needed for the benefit of air carriers, which is comparable to those governing international and surface transportation, and Federal legislation is preferable to avoid the uncertainties and lack of uniformity of State laws or regulations.

Analysis of the Civil Aeronautics Board's Precedents in Safety Enforcement Cases. Merrill Armour and Harley G. Moorhead, Jr. *Journal of Air Law and Commerce*, Vol. 17, No. 1, Winter, 1950, pp. 54–76.

Position of the Certificated Air Carriers in Civil Aeronautics Board Freight Proceedings. E. Smythe Gambrell and Charles A. Moye, Jr. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 3–16.

How Not to Regulate Air Transportation. James A. Durham. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 105–121. Critique of the policies and decisions of the Civil Aeronautics Board and its staff members.

The Illusion of Air Line Subsidy. Carleton Putnam. *Journal of Air Law and Commerce*, Vol. 17, No. 1, Winter, 1950, pp. 32–42.

Discussion of the economic aspects of air-mail pay and its relation to subsidy payments made by the Government to surface transportation organizations and other interests.

The Position of the Freight Carriers Before the Civil Aeronautics Board. Stephen Ailes. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 17–28.

State Sovereignty in the Navigable Airspace. Madeline C. Dinu. *Journal of Air Law and Commerce*, Vol. 17, No. 1, Winter, 1950, pp. 43–53.

The "Air Coach" Experiment and National Air Transport Policy. I. Harold A. Jones and Frederick Davis. *Journal of Air Law and Commerce*, Vol. 17, No. 1, Winter, 1950, pp. 1–21.

Air Freight and Air Express. Peter W. Wilson. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 37–46.

Statistical Controls and the Regulation of Air Cargo. Marc J. Feldstein. *Law and Contemporary Problems*, Vol. 15, No. 1, Winter, 1950, pp. 97–104.

State Crop Dusting and Spraying Regulations and Number of Aircraft. *Aviation Operations*, Vol. 13, No. 2, February, 1950, pp. 24, 25. Includes tabulation by states of crop dusting and spraying regulations and the number of aircraft in each state.

Machine Elements (14)

FASTENINGS

Flush Head Screw Allowables in 24ST Alclad Sheet Joints. Harold G. Brilmyer. *Product Engineering*, Vol. 21, No. 3, March, 1950, pp. 109–112, illus.

FRICTION

Surface Deformation and Friction of Metals at Light Loads. J. R. Whitehead. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 201, No. 1064, March 7, 1950, pp. 109–124, illus. 10 references.

Friction was measured under controlled conditions of sliding at loads ranging from a few milligrams to several kilograms. The deformation of electrolytically polished copper surfaces that were studied by light and electron microscopy showed a departure from Amonton's law where the normal load was less than a few grams. This is attributed to the effect of the thin oxide formed by contact with the atmosphere. Thicker films of oxide formed by heating in air reduced the friction at heavy load. The influence of surface roughness upon friction was not great. The friction of silver on silver and of aluminum on aluminum was constant, and Amonton's law held over the whole range of loads. Isolated experiments on sapphire and diamond showed the coefficient of friction to be low and constant for these nonmetals. In spite of the deviations from Amonton's law on some metals, the results of all the experiments on dry sliding emphasize the essential similarity of the frictional process and of the basic mechanism over an enormous range of loads.

Maintenance (25)

The Evolution of Royal Air Force Servicing Schedules. I. II. James H. Stevens. *Aircraft Engineering*, Vol. 22, Nos. 251, 252, January, February, 1950, pp. 12–19; 40–45; illus. 10 references.

A detailed account of the preparation of maintenance schedules from the first-line or daily routine check to the fourth-line or major overhaul of engines and airplanes, and an explanation of the duties of workmen and supervisors.

Cabin Supercharger Overhaul Workshop; K. L. M. Maintenance. L. Visser. *Shell Aviation News*, No. 139, January, 1950, pp. 18–20, illus.

Allied Maintenance at Gander. James H. Winchester. *Aviation Operations*, Vol. 13, No. 3, March, 1950, pp. 21, 22, 48, illus.

Instead of Hammer and Chisel; Know Your (Gear) Pullers. A. R. Kaplan. *Aviation Operations*, Vol. 13, No. 3, March, 1950, p. 44, illus.

Boeing Service Guide, Nos. 29, 30, February, March, 1950. 8 pp., illus. Model 377 Stratocruiser.

Douglas Service, Vol. 8, No. 1, January-February, 1950. 21 pp., illus. C-54, DC-3, DC-4, DC-6.

Manual of Organization of Overhaul & Repair Department. *U.S. Naval Air Station, Pensacola, Florida*, March 1, 1949. 128 pp., illus.

NAS Squantum's Automatic Fire Protection. *Aviation Operations*, Vol. 13, No. 2, February, 1950, p. 30, illus.

The built-in automatic carbon dioxide fire-extinguishing system installed in the carburetor-test room at the Naval Air Station, Squantum, Mass.

Materials (8)

Aircraft Materials from the Designer's Point of View. A. E. Russell. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 200–235, Discussion, pp. 235–241, illus.

The close agreement of theoretical and experimental studies of aircraft structures strengthened for local torsional and flexural instability and skin buckling by means of Z-section, inverted Y-section, and hat-section stiffeners shows that theoretical analysis provides a practical and rational basis for the selection of materials. Variation in dimensions, strength, and directional properties of sheet metals and extrusions demonstrates that in certain circumstances it is possible to make better use of a material than that indicated by the limitations of normal specifications.

Materials from the Aircraft Manufacturer's Point of View. P. Litherland Teed. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 242–321, Discussion, p. 321, illus. 91 references.

The greatest need of the designer of air frames or engines is a broader practical knowledge of the properties of metallic materials, suitable for the conditions encountered in flight. A comprehensive survey of the chemical, electrical, and mechanical properties of metals under stratospheric conditions shows that the influence of very low temperature, atmospheric pressure, and humidity on materials cannot be ignored, but by the exercise of

discrimination all difficulties introduced by these conditions can be overcome. Fatigue, which accounts for a large majority of the failures of aircraft parts, results from stresses above and below the elastic limits, cyclic stresses, crystal size, grain size, heat treatment, impurities, surface conditions, notches, and the effects of machining or fabricating operations. Those and other influences are the bases for the estimation of the service life of metal aircraft parts and structures.

Materials in the Aircraft Industry. Clyde Williams. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 312–321, illus.

A review of present knowledge of structural materials for aircraft, which indicates the major gaps in that information, forecasts possible new materials for the future and designates some factors that influence the choice of materials. In designing aircraft components, the limitations are elastic stability on one hand and plastic stability or fracture on the other. The knowledge of the elastic properties of aluminum and magnesium alloys and the steels is reasonably adequate for current practice. Although conventional tensile-property data for plastic stability and fracture are abundant for most materials, the lack of fundamental understanding of fatigue data is a handicap. Further information is needed to deal with elevated temperatures. Titanium and its alloys are potentially attractive for that field because of their high strength-weight ratios and corrosion resistance. Ceramics have attractive elastic and density properties, but many strength problems remain to be solved.

METALS & ALLOYS

The Theory of Plane Plastic Strain for Anisotropic Metals. R. Hill. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 198, No. 1054, August 22, 1949, pp. 428–437, illus. 6 references.

A yield criterion and plastic stress-strain relations are formulated for anisotropic metals deformed under conditions of plane strain. The equations are hyperbolic, their characteristics coinciding with the directions of maximum shear strain-rate. When the anisotropy is uniformly distributed, the variation of the stresses along the characteristics is expressed in terms of elliptic functions, and geometrical properties of the field of characteristics are established. The theory is applied to the problem of indentation by a flat die.

The Effect of Thermal Cycles on the Structure of Alloys; Diffusion Effects in Two Phase Alloys. R. J. Davis and W. Hume-Rothery. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 200, No. 1063, February 22, 1950, pp. 441–458, illus. 11 references.

The Determination of Static and Dynamic Yield Stresses Using a Steel Ball. R. M. Davies. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 197, No. 1050, June 22, 1949, pp. 416–432, illus. 13 references.

Les Alliages Légers a Haute Résistance. A. Guinier. *La Recherche Aéronautique*, No. 9, May-June, 1949, pp. 3–8, illus. 5 references.

Hastelloy. *Union Carbide and Carbon Corp., Haynes Stellite Division, Booklet*, 40 pp., illus. Descriptions and tables of the chemical composition, physical, mechanical, and corrosion-resistance properties and the methods of Hastelloy alloys A, B, C, and D.

Readers' Forum: Stability of Alclad Plates. P. P. Bijlaard. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, p. 252. 2 references.

NONMETALLIC MATERIALS

The Outlook for Ceramics in Gas Turbines. W. H. Duckworth and I. E. Campbell. *Mechanical Engineering*, Vol. 72, No. 2, February, 1950, pp. 128–130, 144. 2 references.

Survey of progress in the use of ceramic bodies as stator and rotor blades and for combustion chambers, and of ceramic coatings for metals in such applications.

Analysis of Ceramics for Jet Engine Use. *Aviation Week*, Vol. 52, No. 11, March 13, 1950, pp. 21, 22, 24, 27.

Rubber as a Stress-Carrying Material and Some Design Considerations. S. W. Marsh. *Institution of Mechanical Engineers, Proceedings, Automobile Division, Part II*, 1948–49, pp. 25–30, Discussion, pp. 31–41, illus.

Stress-Strain Curves for Fatigued Rubber. D. F. Stedman. *Canadian Journal of Research, Section F, Technology*, Vol. 28, No. 2, February, 1950, pp. 31–49, illus. 9 references.

Imprégnation des Bois par les Résines Synthétiques. Marie Falinski. *La Recherche Aéronautique*, No. 8, March-April, 1949, pp. 19–28, illus. 12 references.

Méthode d'Étude de la Polymérisation des Résines Thermodurcissables. M. Girouard. *La Recherche Aéronautique*, No. 8, March-April, 1949, pp. 29–31, illus. 3 references.

Propriétés Mécaniques du Nylon aux Faibles Humidités. Jacqueline Beaudoux. *La Recherche Aéronautique*, No. 9, May-June, 1949, pp. 29–32, illus. 4 references.

Effect of Alkalinity of Phenol- and Resorcinol-Resin Glues on Durability of Joints in Plywood. R. F. Blomquist. *U.S., Forest Products Laboratory, Madison, Wis., Report No. R1748*, August, 1949. 24 pp. 2 references.

Properties of a Boron Carbide-Iron Ceramal. W. G. Lidman and H. J. Hamjian. *U.S., N.A.C.A., Technical Note No. 2050*, March, 1950. 23 pp., illus. 7 references.

PROTECTIVE COATINGS

A Determination of the Fire-Retardant Properties of Paints. A. W. Van Heuckeroth, George S. Cook, and Roy W. Hill. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 15, No. 4, April 1, 1950, pp. 27–30, illus.

SANDWICH MATERIALS

Durability of Low-Density Core Materials and Sandwich Panels of the Aircraft Type as Determined by Laboratory Tests and Exposure to the Weather. II. Bruce G. Heebink, William J. Kommers, and Alvin A. Mohaupt. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1573-A*, July, 1949. 30 pp., illus.

Structural Foils for Greater Strength. R. E. Higgins and G. G. Havens. *Automotive Industries*, Vol. 102, No. 6, March 1, 1950, pp. 24–26, 52, illus.

Meteorology (30)

Dynamic Models Illustrating the Energy Balance of the Atmosphere. Edward N. Lorenz. *Journal of Meteorology*, Vol. 7, No. 1, February, 1950, pp. 30–38, illus. 6 references.

A generalized vorticity equation for a two-dimensional spherical earth is obtained by eliminating pressure from the equations of horizontal motion which include friction. The generalized vorticity equation is satisfied by formal infinite series representing the density and wind fields. The first few terms of a particular series solution are obtained explicitly. The series appear to converge near the north pole and determine a model of a polar air mass. Within the air mass, the coldest winds are northeasterly and the warmest are southwesterly, while the coldest air of all is at the north pole. Heating occurs in the northwesterly winds and cooling in the southeasterlies, while aside from the effect of friction the air mass as a whole is cooled. An analogous distribution of heating and cooling may be instrumental in maintaining the general circulation of the atmosphere.

A Note on Polar Air-Mass Modification. R. Frost. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 198, No. 1052, July 22, 1949, pp. 27–38, illus. 9 references.

Formulas are derived for the increase of temperature and moisture content in polar air that passes over a warm sea surface. These results are in good agreement with observations.

The Thermal Equilibrium at the Tropopause and the Temperature of the Lower Stratosphere. R. M. Goody. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 197, No. 1051, September 7, 1950, pp. 487–505, illus. 19 references.

Synoptic Studies of the Potential Energy in Cyclones. Jerome Spar. *Journal of Meteorology*, Vol. 7, No. 1, February, 1950, pp. 48–53, illus. 11 references.

Note on the Relation Between the Actual Wind and the Geostrophic Wind. Sverre Petterssen. *Journal of Meteorology*, Vol. 7, No. 1, February, 1950, pp. 76, 77, illus. 1 reference.

A Meridional Aerological Cross Section in the Southwest Pacific. F. Loewe and U. Radok. *Journal of Meteorology*, Vol. 7, No. 1, February, 1950, pp. 58–65, illus. 32 references.

Variations in the Structure of the Upper Westerlies. George P. Cressman. *Journal of Meteorology*, Vol. 7, No. 1, February, 1950, pp. 39–47, illus. 11 references.

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A Proposed Mechanism of Squall Lines; The Pressure Jump Line. Morris Tepper. *Journal of Meteorology*, Vol. 7, No. 1, February, 1950, pp. 21–29, illus. 16 references.

Wind and Temperatures in the Lower Stratosphere. C. J. Brasefield. *Journal of Meteorology*, Vol. 7, No. 1, February, 1950, pp. 66–69, illus. 9 references.

Tidal Effects in the Ionospheric F-Layer. M. W. Jones and J. G. Jones. *Journal of Meteorology*, Vol. 7, No. 1, February, 1950, pp. 14–20, illus. 12 references.

Atmospheric Refraction at Low Angular Altitudes in the Tropics. Charles H. Smiley. *Navigation*, Vol. 2, No. 5, March, 1950, pp. 110–113. 3 references.

Research into Clear Air Gusts. *The Aeroplane*, Vol. 78, No. 2020, February 24, 1950, pp. 237, 238, illus.

Further Studies in Hawaiian Precipitation. Samuel B. Solot. *U.S. Weather Bureau, Research Paper No. 32*, January, 1950. 37 pp., illus. 15 references.

La Haute Atmosphère; Résumé d'une Synthèse des Connaissances sur la Haute Atmosphère. J. Delarbre. *La Recherche Aéronautique*, Nos. 8, 9, March-April, May-June, 1949, pp. 63, 64; 57–59; illus.

Les Dimensions des Noyaux de Condensation Déduites de l'Étude de l'Équilibre Ionique de la Basse Atmosphère. J. Bricard. *La Recherche Aéronautique*, No. 5, September-October, 1948, pp. 63, 64. 9 references.

Thermodynamique de l'Atmosphère. J. van Mieghem and L. Dufour. *Belgium, Institut Royal Météorologique, Mémoires*, Vol. 30, 1948. 247 pp., illus. 29 references.

La Température de la Stratosphère. J. Roulleau. *Journal Scientifique de la Météorologie*, Vol. 1, No. 3, July–September, 1949, pp. 70, 71. 7 references. (English Summary.)

Note sur une Méthode de Kibel pour la Prévision du Temps. M. Kiveliovitch. *Journal Scientifique de la Météorologie*, Vol. 1, No. 3, July–September, 1949, pp. 72–74. 3 references. (English Summary.)

Abaques pour le Calcul de la Quantité d'Eau Précipitable. R. Eyraud. *Journal Scientifique de la Météorologie*, Vol. 1, No. 3, July–September, 1949, pp. 75–90, illus. (English Summary.)

Sur une Méthode d'Examen des Particules de Brouillard par Fixation sur Papier Photographique. A. Avy and R. Railleres. *Journal Scientifique de la Météorologie*, Vol. 1, No. 3, July–September, 1949, pp. 91–100, illus. 2 references. (English Summary.)

Quelques Problèmes Fondamentaux pour les Études de la Radiation. M. Nicolet. *Journal Scientifique de la Météorologie*, Vol. 1, No. 1, January–March, 1949, pp. 2–13, illus. 2 references.

Influence Conjuguée du Rayonnement et de la Convection sur les Mesures de Température dans les Sondages Aérologiques; Effet Radiaconvectif. M. Petit. *Journal Scientifique de la Météorologie*, Vol. 1, No. 4, October–December, 1949, pp. 122–130, illus. 5 references.

Détermination des Routes Aériennes a Durée Minimum. J. Bessemoulin and R. Pone. *Journal Scientifique de la Météorologie*, Vol. 1, No. 4, October–December, 1949, pp. 102–121, illus. 11 references.

L'Effet de la Température sur les Bandes de Chappuis de l'Ozone Aspect Geophysique. E. Vassy. *Journal Scientifique de la Météorologie*, Vol. 1, No. 1, January–March, 1949, pp. 14–17. 8 references. (English Summary.)

Sur la Composante Verticale du Vent. M. Kiveliovitch. *Journal Scientifique de la Météorologie*, Vol. 1, No. 1, January–March, 1949, pp. 18–22. 2 references. (English Summary.)

Influence des Courants Verticaux sur les Avions. R. Eyraud. *Journal Scientifique de la Météorologie*, Vol. 1, No. 1, January–March, 1949, pp. 23–31, illus. (English Summary.)

À Propos d'une Étude des Vents en Altitude. J. Mondain. *Journal Scientifique de la Météorologie*, Vol. 1, No. 2, April–June, 1949, pp. 48–52, illus. (English Summary.)

Production et Redistribution de la Quantité de Mouvement et de l'Énergie Cinétique dans l'Atmosphère; Application à la Circulation Atmosphérique Générale. J. van Mieghem. *Journal Scientifique de la Météorologie*, Vol. 1, No. 2, April–June, 1949, pp. 53–67. 10 references. (English Summary.)

Military Aviation (24)

The Balance of World Power. Walter Lippmann. *Aeronautical Engineering Review*, Vol. 9, No. 3, March, 1950, pp. 30–33, illus.

Air Force Research and Development. Donald L. Putt *Aeronautical Engineering Review*, Vol. 9, No. 3, March, 1950, pp. 41–43, illus.

Current Research and Development Trends in Naval Aviation. C. M. Bolster. *Aeronautical Engineering Review*, Vol. 9, No. 3, March, 1950, pp. 38–40, illus.

Air Power in the Arctic. *The Aeroplane*, Vol. 78, No. 2023, March 17, 1950, pp. 314, 315, illus.

Berlin Airlift Proved Unification Can Work. Brendan P. Mulready. *U.S. Naval Institute, Proceedings*, Vol. 76, No. 3, March, 1950, pp. 282–287, illus.

La Academia General del Aire. José Manuel Izquierdo Sánchez-Prado. *Avión* (Madrid), Vol. 4, No. 42, August, 1949, pp. 334–337, illus.

La Fuerza Aerea Portuguesa. Miguel Sanchis. *Avión* (Madrid), Vol. 4, No. 35, January, 1949, pp. 22–24, illus.

La Aviación Militar Española. Miguel Sanchis. *Avión* (Madrid), Vol. 4, No. 42, August, 1949, pp. 318–321, 358, illus.

Tríptico de la Elogioso Aviación Militar Española. F. E. Ezquerro. *Avión* (Madrid), Vol. 4, No. 42, August, 1949, pp. 330–333, 353, illus.

Model Airplanes

Works Within a Works; Craftsmanship in a Model-Shop of the de Havilland Enterprise. *Flight*, Vol. 57, No. 2150, March 9, 1950, pp. 316, 317, illus.

Navigation (29)

The Future of Air-Traffic Control; Symposium of Papers Read to Institute of Navigation (February 17, 1950). *Flight*, Vol. 57, No. 2149, March 2, 1950, pp. 276, 277.

The Common System of Air Navigation and Traffic Control. I—The Transition Program. J. H. Dellinger. *Navigation*, Vol. 2, No. 5, March, 1950, pp. 103–109.

Test-Flight Navigation; Practical Experience with the Decca Navigator System in the Ambassador. *Flight*, Vol. 57, No. 2149, March 2, 1950, pp. 274–276, illus.

Flying Offset Courses Using Radar Beacons Between LaGuardia and Washington in Conjunction with Stabilized Azimuth Overlay on AN/APS-10 PPI. *American Airlines System, Flight Engineering Operational Flight Research, Flight Test Report No. 62 [Navy Contract NOa(s)-9006]*, January 28, 1949. 4 pp., illus.

London Radar; Long-Range Radar Monitoring Service Centred at London Airport. *Flight*, Vol. 57, No. 2147, February 16, 1950, pp. 208, 209, illus.

The Services of Southern Radar. *The Aeroplane*, Vol. 78, No. 2019, February 17, 1950, pp. 191–193, illus.

Le Point Astronomique à Terre sans Instrument. Robert Genty. *France Ministère de l'Air, Publications Scientifiques et Techniques, Bulletin de Service Technique, No. 111*, September, 1949. 69 pp., illus. Service de Documentation et d'Information Technique de l'Aéronautique, Paris. 300 Fr.

Méthodes Pratiques de Calcul pour la Distance Zénithale Solaire. E. Argence. *France, Ministère de l'Aire, Publications Scientifiques et Techniques, Note Technique No. 31*, June, 1949. 15 pp., illus. 7 references. Service de Documentation et d'Information Technique de l'Aéronautique, Paris. 150 Fr.

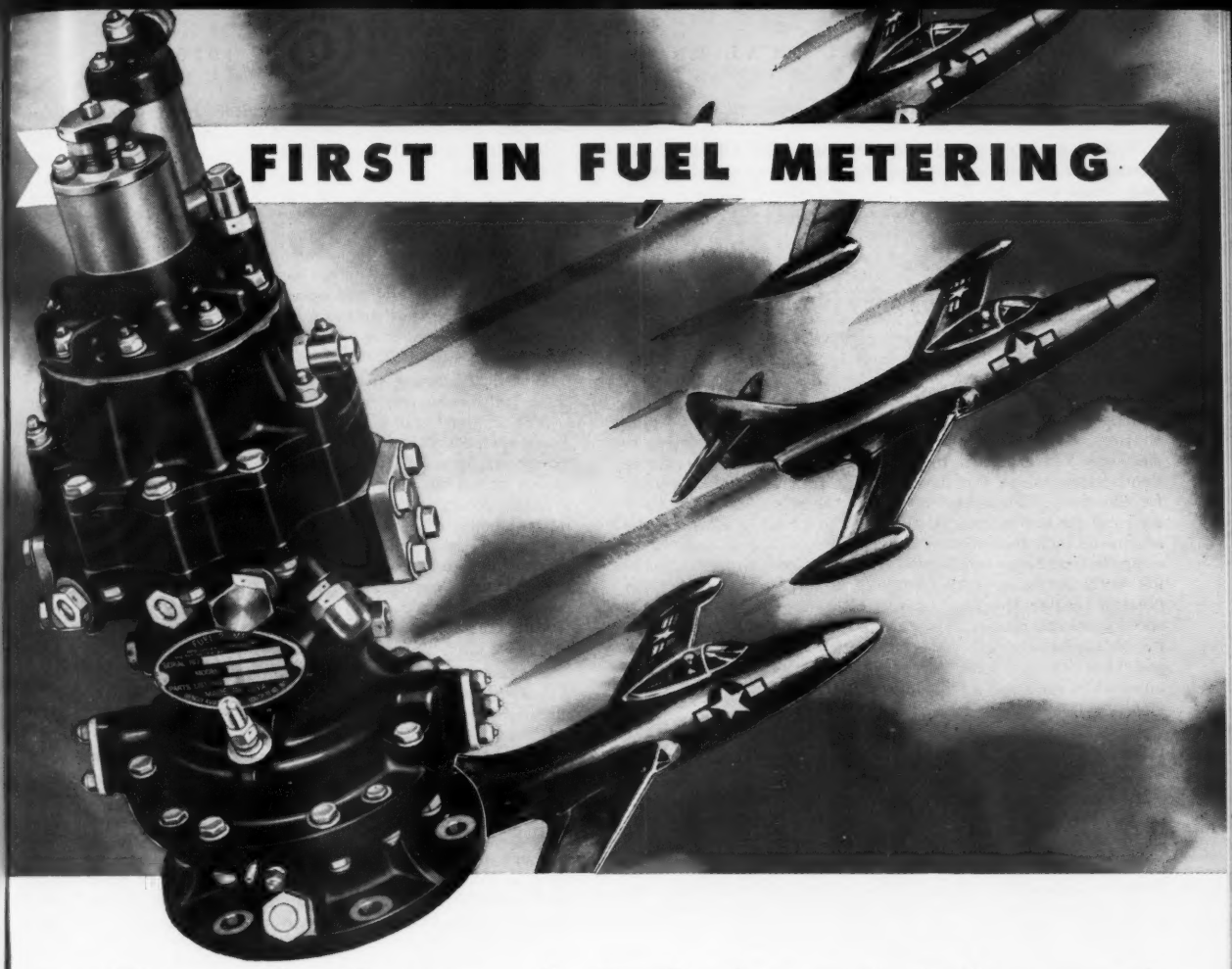
Le Temps de Propagation des Ondes Électromagnétiques dans la Troposphère; Contribution à une Théorie de la Navigation Précise. G. Eckart. *La Recherche Aéronautique*, No. 9, May-June, 1949, pp. 43–46, illus. 2 references.

Conditions Géodesiques d'un Radiophare Directionnel; Contribution à la Théorie de la Navigation Précise. G. Eckart. *La Recherche Aéronautique*, No. 10, July-August, 1949, pp. 61–64, illus.

Altérations Systématiques Écartant la Verticale Apparente de la Verticale Vraie a Bord d'un Mobile. J. Bouzitat. *La Recherche Aéronautique*, No. 10, July-August, 1949, pp. 33–42, illus.

Organizations & Societies (46)

Impressions of the I.A.S. Eighteenth Annual Meeting. I. Stephen J. Zand. *Aeronautical Engineering Review*, Vol. 9, No. 3, March, 1950, pp. 34–37, 51, illus.



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Parachutes

Spin-Tunnel Investigation to Determine the Effect on Spin Recoveries of Reducing the Opening Shock Load of Spin-Recovery Parachutes. Ira P. Jones, Jr., and Walter J. Klinar. *U.S., N.A.C.A., Technical Note No. 2051*, March, 1950. 29 pp., illus. 4 references.

Photography (26)

Synchronized Air-Borne Camera System. V. J. White and S. J. Horwitz. *Electrical Engineering*, Vol. 69, No. 4, April, 1950, pp. 324–327, illus.

Displacement control is obtained by synchronizing the 3,600-r.p.m. camera-drive motors with pulses from the 1,200-r.p.m. shutters, and velocity control is obtained without resorting to electrical differentiation in a method of aerial motion-picture photography which was developed at Northwestern University for the Navy. Films are exposed at the rate of 20 frames per sec., and the cameras are synchronized to within 0.002 sec. The apparatus includes a timing system for relating all data to an accurate time base; oscillograph recording for continuous checking of the accuracy of the motor-control system and for interpolating the data to a higher degree of accuracy if required; high-speed flashlamp illumination with flashes of 0.00004-sec. duration for photographing fast-moving dial indicators; film coding for matching the film from different cameras; and a radio communication system for relating the data and controlling equipment carried in two or more aircraft.

Aerial Survey of Southeastern Alaska, 1948. Thomas F. Pollock. *U.S. Naval Institute, Proceedings*, Vol. 76, No. 3, March, 1950, pp. 302–307, illus.

Moderna Apparecchiatura Nistri per la Costruzione delle Carte Aerofotogrammetriche. G. Boaga. *L'Aerotecnica*, Vol. 29, No. 5, October 15, 1948, pp. 260–263, illus.

Quelques Vues Nouvelles sur la Photographie au Gélatino-Bromure d'Argent. F. J. Taboury and J. Salvinien. *La Recherche Aéronautique*, No. 6, November-December, 1948, pp. 47–55, illus. 14 references.

Power Plants

Power for Flight. *Aeronautics*, Special Trilingual Edition, 1950, pp. 104–106, 109, 110, 113, illus. Descriptions of British gas-turbine power plants.

Works Organization; Planning and Manufacturing Facilities for Research and Development of Aircraft Engines. J. S. Paget. *Aircraft Production*, Vol. 12, No. 138, April, 1950, pp. 133–138, illus.

La Filtration Appliquée aux Moteurs à Combustion. M. Chirac. *Technique et Science Aéronautiques*, No. 2, 1949, pp. 102–106.

Domaine d'Utilisation des Moteurs à Pistons et des Turbo-Machines en Aéronautique. M. L. Laming. *Technique et Science Aéronautiques*, No. 2, 1949, pp. 109–123, illus.

JET & TURBINE (5)

Recent Design Refinements in Turbojet Engines. N. Burgess and J. C. Buechel. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 78–85, Discussion, pp. 85–88, illus.

Heating and inlet guide vanes, struts, and fairings provide a practical method of preventing ice accretion in axial gas turbines, according to tests on the ground, on mountain tops, and in flight, under icing conditions at temperatures ranging from −3° to 31°F. Hot-air heating is superior to electrical heating, and the high-pressure, heated air leaving the guide vanes has important secondary uses. Thrust augmentation of about 18 per cent under sea-level static conditions can be obtained by injection of water or alcohol-water mixtures into the combustion chamber at the rate of about 25 lbs. of fluid per hour per pound of thrust of approximately one per cent. Exhaust reheat, or afterburning, increases engine thrust by 40 per cent under sea-level static conditions and by substantially higher percentages in flight, at a cost of 12 to 15 per cent in engine weight, giving one pound of additional thrust for each 6 lbs. of additional fuel per hour.

The Propeller Gas Turbine in Service. F. M. Owner. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 23–73, Discussion, pp. 73–77, illus.

A report on the operational experience of the Royal Air Force Transport Command with Bristol Theseus turboprop engines which reviews the development of the engine, describes its design and construction, and compares bench-test and flight-test methods and results. The engines have demonstrated a long service life between overhauls, low maintenance costs, reduced fuel and oil consumption, ease and simplicity of control, and satisfactory operation under varying climatic conditions, as well as low noise and vibration levels.

Electrical Starting of Aircraft Jet Engines. P. T. Kunigonis. *Electrical Engineering*, Vol. 69, No. 4, April, 1950, pp. 335, illus.

The adaptation of carbon-pile current and voltage regulators has made possible the development of portable constant-current power-supply units for starting and servicing aircraft jet power plants and other components employing d.c. electrical systems. A single generator supplies d.c. power at 28 volts and constant-current power over a wide range of ceiling voltages. The portable ground unit contains a 4-cylinder air-cooled gasoline engine driving the generator with its cooling fan and exciter, a battery, and necessary control equipment. It delivers 300 amperes of constant current at ceiling voltages between 150 and 250 volts. The air-borne jet-engine starter motor delivers 60 hp. at 175 volts at 2,000 r.p.m., and weighs 97 lbs.

Sweat Cooling. N. P. W. Moore and P. Grootenhuis. *The Engineer*, Vol. 189, No. 4909, February 24, 1950, pp. 230, 231, illus. 6 references.

The correlation of theoretical and experimental data based on a wide range of velocity and temperature studies with pipe and rectangular ducts, using gases and liquids as coolants, demonstrates that the process of sweat cooling is practically independent of the geometry of the system. When applied to a gas turbine, the cooling air is taken from the compressor and goes through the ordinary gas turbine thermodynamic cycle. The power loss in using air from the compressor for sweat cooling is not great, ranging from 1.85 to 9.7 per cent. Extension of the use of sweat cooling will depend on the development of porous material of low but closely controlled permeability, having the necessary mechanical properties and fair resistance to elevated temperatures.

Turbine Engines and Aircraft of the U.S.A.; Turbine Engines. Roy Cross. *Aeronautics*, Vol. 22, No. 4, March, 1950, pp. 26–29, 41.

Summary of the activities of American manufacturers of gas turbines, with descriptions of current products and a table of principal specifications.

Jet Transports—Their Promise and Problems. William Littlewood. *SAE Journal*, Vol. 58, No. 3, March, 1950, p. 17–19. (Extended summary of a paper: Jet Transport Jitters.)

Effect of Heat and Power Extraction on Turbojet-Engine Performance. I—Analytical Method of Performance Evaluation with Compressor-Outlet Air Bleed. Reece V. Hensley, Frank E. Rom, and Stanley L. Koutz. *U.S., N.A.C.A., Technical Note No. 2053*, March, 1950. 52 pp., illus. 4 references.

Chart for Simplifying Calculations of Pressure Drop of a High-Speed Compressible Fluid Under Simultaneous Action of Friction and Heat Transfer; Application to Combustion-Chamber Cooling Passages. Merwin Sibulkin and William K. Koffel. *U.S., N.A.C.A., Technical Note No. 2067*, March, 1950. 27 pp., illus. 10 references.

Analysis of Performance of Jet Engine from Characteristics of Components. II—Interaction of Components as Determined from Engine Operation. Arthur W. Goldstein, Sumner Alpert, William Beede, and Karl Kovach. *U.S., N.A.C.A., Report No. 928*, 1949. 16 pp., illus. 9 references. U.S. Govt. Printing Office, Washington. $0.20.

Inside the (Bristol) Theseus. D. M. Desoutter. *Aeronautics*, Special Trilingual Edition, 1950, pp. 99–103, illus.

Axial-Compressor Blades; Machining Processes on the Light-Alloy Stator Blades of the Bristol Theseus Engine. *Aircraft Production*, Vol. 12, No. 137, March, 1950, pp. 97–101, illus.

Gas-Turbine Auxiliary Powerplants. Paul H. Wilkinson. *Aero Digest*, Vol. 60, No. 3, March, 1950, pp. 30, 31, 134, illus.

Coupled Axial Flow Turbine Engines Drive Contra-Rotating Propellers. *Automotive Industries*, Vol. 102, No. 6, March 1, 1950, pp. 44, 56, illus. The Napier Coupled Naiad.

Shooting a bird...

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THIS IS "shooting a bird" at the U. S. Naval Air Missile Test Center, Point Mugu, California.

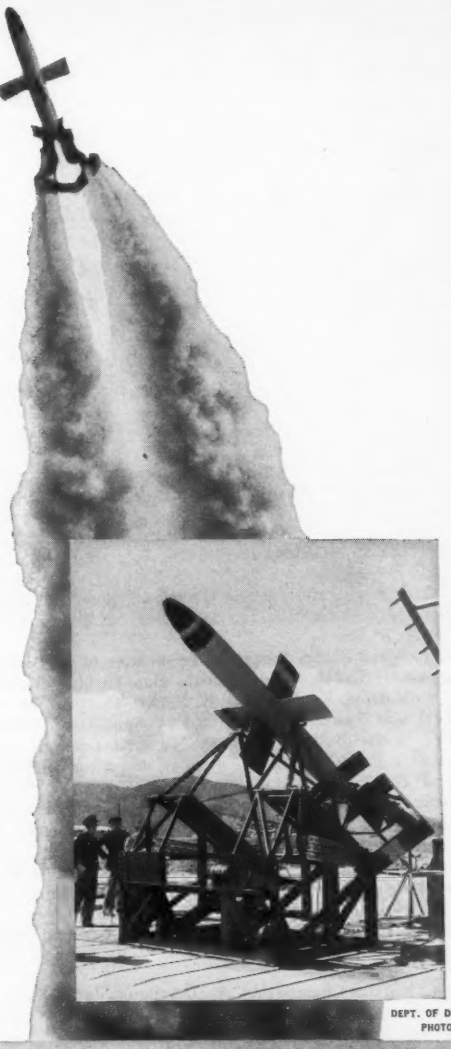
The "shoot" is the launching of a missile, while the "bird", in this particular case, is the Fairchild CTV-N-9a guided missile.

In a matter of seconds the missile is hurled high into the atmosphere with a deafening roar, propelled by its reaction type motors and auxiliary booster. Separation of the booster occurs as the missile speeds higher and higher into space, stabilized and controlled by the "intelligence" of its electronic guidance systems.

Soon the launching crews and ground observers no longer see the missile . . . but its path is being carefully plotted as it hurls toward its target . . . now under its own homing control.

This "shooting a bird" is but one phase of the Lark project. It is an operation requiring split-hair timing and perfect coordination. It is the result of teamwork between the Bureau of Aeronautics, Navy Department, the Naval Research Laboratory and Fairchild engineers and represents a combination of the best in aerodynamic design, electronic controls and precision manufacturing.

Here is another example of a Fairchild *first* and of "shooting a bird" . . . in the Air Age.



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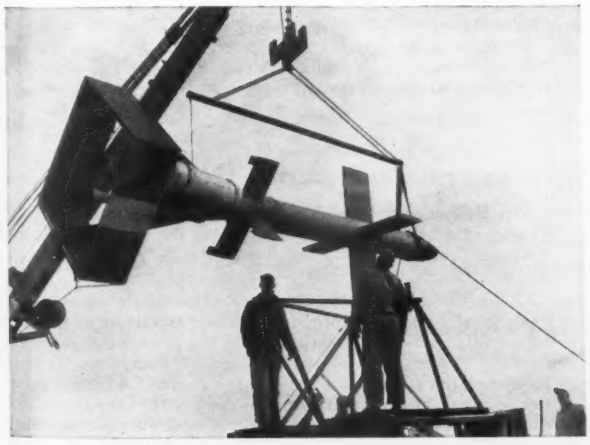

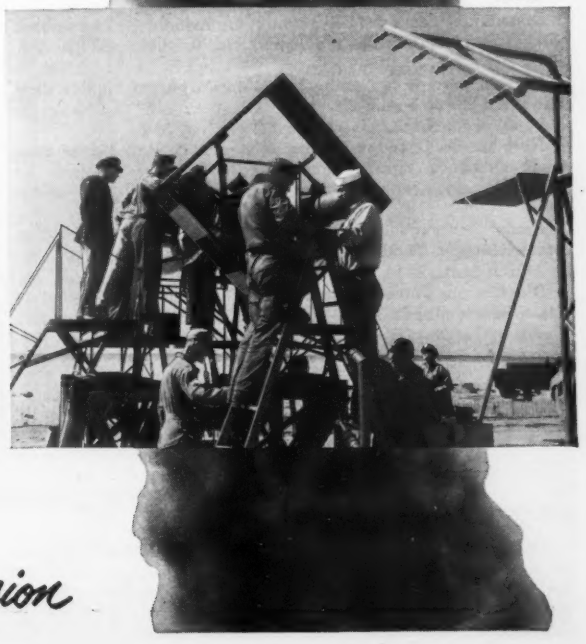

ENGINE AND AIRPLANE CORPORATION

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FARMINGDALE, LONG ISLAND, N. Y.

Mamba Dakota; Installation of Turbo-Props to Meet ICAO Requirements. D. O. MacDougall. *Shell Aviation News*, No. 139, January, 1950, pp. 14–17, illus.

Fuel Systems for Gas Turbines. I. II. R. A. Fry. *The Technical Instructor*, Vol. 5, Nos. 1, 2, January, February, 1950, pp. 9–13; 9–15, illus.

Detailed descriptions of various British fuel-supply systems, with explanations of their principal parts and methods of operation.

Turbojet Engine Lube Problem Aided by Supplemental Lubes, Additives. Edmond E. Bisson and Robert L. Johnson. *SAE Journal*, Vol. 58, No. 3, March, 1950, pp. 39–41, illus. (Extended summary of a paper: Lubrication, Friction, and Wear Studies for High-Output Aircraft Engines.)

Internal Combustion Turbine Testing Equipment Engine Laboratory. M. S. Kuhring. *Canada, National Research Council, Aeronautical Laboratories, Report No. ME 1949 (4)*, October 1–December 31, 1949, pp. 1–10, illus.

The Gas Turbine Cycle with Water Injection into the Compressor. P. Chambadal. (*Chaleur et Industrie*, Vol. 30, No. 292, November, 1949, pp. 257–269.) *The Engineers' Digest*, Vol. 11, No. 3, March, 1950, pp. 77–80, 100, illus.

Blade Inspection; Sigma Electric Transmitting Gauges Used to Give Dimensional Indication of Profile Variations. *Aircraft Production*, Vol. 12, No. 138, April, 1950, pp. 120–122, illus.

Machining Gas-Turbine Impellers; Special-Purpose Equipment at the de Havilland Engine Co., Ltd. S. C. Poulsen. *Aircraft Production*, Vol. 12, No. 138, April, 1950, pp. 125–130, illus.

Making Rotors and Turbine Wheels for Newest Allison 400 Jet Engine. *Automotive Industries*, Vol. 102, No. 7, April 1, 1950, pp. 38, 39, 76, 78, illus.

High-Speed Blade-Checking; Application of the Sigma Multidimensional Checking Machine to Gas-Turbine Blades. *Aircraft Production*, Vol. 12, No. 137, March, 1950, pp. 73–75, illus.

How Gas Turbines Erode Told by Sand-Dust Tests. J. E. DeRemer. *SAE Journal*, Vol. 58, No. 3, March, 1950, pp. 68–70, illus. (Extended summary of a paper: Sand and Dust Erosion in Aircraft Gas Turbines.)

Alcuni Risultati de Ricerche su Turbomotori a Gas. L. Lazzarino. *L'Aerotecnica*, Vol. 28, No. 6, December 15, 1948, pp. 299–304. 31 references.

Caratteristiche de Volo Degli Aerei a Reazione a Velocita Iposonica. A. Lausetti. *L'Aerotecnica*, Vol. 28, No. 6, December 15, 1948, pp. 312–320, illus. 6 references.

Un Nuovo Tipo de Stadio di Compressione per Compressori Assiali. Gianni Jarre. *L'Aerotecnica*, Vol. 28, No. 4, August 15, 1948, pp. 198–205, illus.

Le Calcul des Champs de Caractéristiques de Turbines. M. H. Hausenblas and M. M. Lamblin. *Technique et Science Aéronautiques*, No. 3, 1949, pp. 160–164. 6 references.

Installation des Turbo-Réacteurs sur Avion. G. Otfinovsky. *Technique et Science Aéronautiques*, No. 6, 1948, pp. 329–365, illus.

Le Problème de la Combustion d'un Carburant Liquide dans une Chambre de Turbo-Réacteur. Claude Fouré. *La Recherche Aéronautique*, No. 8, March-April, 1949, pp. 5–8.

Note sur les Grandeurs Caractéristiques de l'Air Utilisé dans la Propulsion à Vitesse Supersonique. Jacques Nicolas. *La Recherche Aéronautique*, No. 8, March-April, 1949, pp. 43–52, illus.

Remarques sur la Pression Optimum de Sortie du Jet d'un Stato-Réacteur. Louis Viaud. *La Recherche Aéronautique*, No. 8, March-April, 1949, pp. 53–61, illus. 2 references.

Diagrammes Universels pour l'Étude du Rendement Global du Stato-Réacteur et du Turbo-Réacteur Simple. Maurice Roy and Georges Gorge. *France, Office National d'Études et de Recherches Aéronautiques, Publication No. 15*, 1948. 126 pp., illus.

Turbo-Réacteur a Double Flux. Maurice Roy, Pierre Duban, and Georges Gorge. *France, Office National d'Études et de Recherches Aéronautiques, Publication No. 14*, 1948. 91 pp., illus.

RECIPROCATING (6)

Trial of a Twin Lubrication System on an Aircraft Engine. George A. Roth and T. R. Salter. *The Texas Agricultural & Mechanical College System, Texas Engineering Experiment Station, Research Report No. 10*, January, 1950. 16 pp., illus. 2 references.

Results indicate that an oil system with duplicate gear pumps, oil screens, check valves, oil pressure gages, and two standpipes at different oil levels is practicable. Such an installation permits engine operation on either or both lubrication systems, and it indicates low oil supply whenever the oil level falls below a safe minimum. An oil tank filler neck baffle arrangement was tested which prevented dangerous loss of oil with the cap removed. The system with its adjuncts could prevent a substantial portion of the airplane accidents that result from faulty oil systems.

Alfa Romeo, Alfa 115 Ter. *L'Ala* (Rome), Vol. 5, No. 4, February 15, 1949, p. 3.

Icing of Aero Engines. G. B. Bolt. *New Zealand Flying*, No. 29, January 16, 1950, pp. 8, 9, illus.

Produzione Motoristica Isotta Fraschini. *L'Ala* (Rome), Vol. 5, No. 7, April 1, 1949, pp. 5–7, illus.

Le Moteur Luetia L 32, 36 CV. *Aéro Club de France, Revue*, No. 2, February, 1949, p. 28, illus.

Étude Graphique du Fonctionnement des Pompes et Injecteurs pour Moteurs a Combustion Interne. R. Kling and R. Jean. *La Recherche Aéronautique*, No. 6, November-December, 1948, pp. 15–22, illus. 7 references.

Ricerche Tedesche sui Radiatori d'Aeroplano. B. Lattanzi. *L'Aerotecnica*, Vol. 28, No. 6, December 15, 1948, pp. 305–311, illus.

Aviation Tooling Adopted for Aircooled Military Engines. *Automotive Industries*, Vol. 102, No. 4, February 15, 1950, pp. 50–52, 54, illus.

Cylinder Head Temperatures in Four Airplanes with Continental A-65 Engines. S. H. Lowy. *Oregon State College, Engineering Experiment Station, Bulletin No. 27*, July, 1949. 43 pp., illus. 9 references.

ROCKET (4)

Two Aspects of Rocket Flight. R. H. Macmillan. *Aircraft Engineering*, Vol. 22, No. 252, February, 1950, pp. 46, 47.

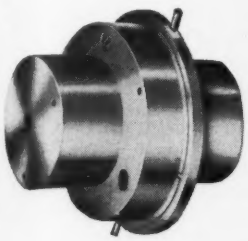
Stability can be achieved by moving the center of pressure of the rocket backward by installing fins at the tail while the center of gravity is brought forward. When the use of fins is undesirable the rocket can be spun like an artillery shell, using the gyroscopic forces to provide a couple that opposes the aerodynamic overturning couple. Since spiral rails on the launcher acting like a rifled gun barrel produce a torque reaction and cause high fuel consumption, it is better to tilt the axes of the thrust nozzles to give a torsional force component as well as a thrust component. A four-stage rocket projectile capable of transporting a pay load of 10 lbs. outside the earth's gravitational field should have a total weight of not less than 10 tons.

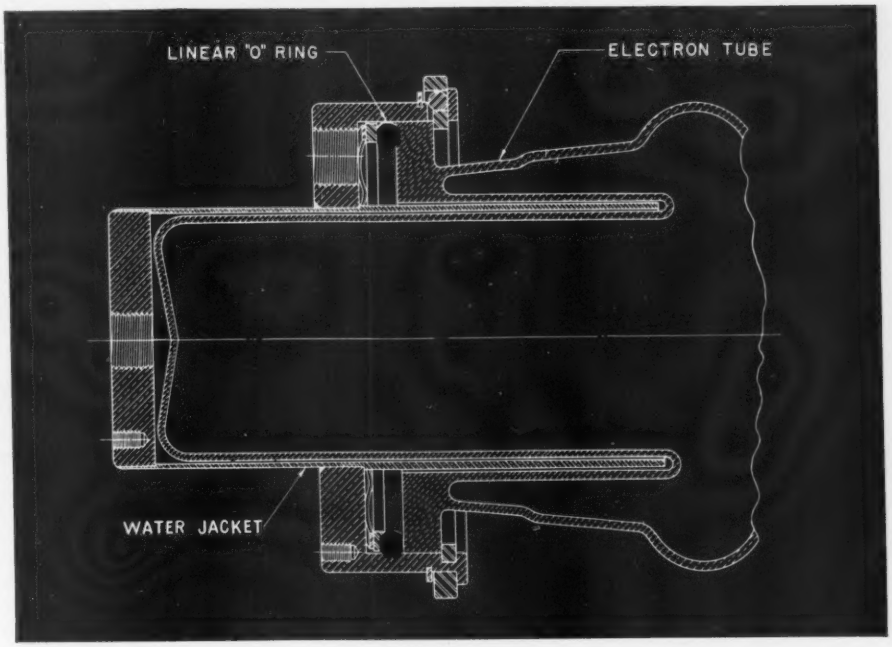
Features of the Sprite. A. V. Cleaver. *de Havilland Gazette*, No. 55, February, 1950, pp. 2–4, illus. The operating principles of the Sprite assisted-take-off rocket and its associated equipment.

Production (36)

The Reduction in Weight of Structurally Important Aircraft Components by Controlled Cold-Working During Manufacture. J. G. H. Brown. *Royal Aeronautical Society, Journal*, Vol. 54, No. 471, March, 1950, pp. 211–214, illus.

Cold working is suggested to increase the ultimate tensile stress, proof stress, and limit of proportionality of aluminum alloys used for aircraft parts. The objection that the process decreases the ductility or elongation is not valid, since a high degree of that property is not essential for the parts in question. A second objection, that exact calculation cannot be made of the improvement of the properties, is answered by using cold work only in connection with straight spars, booms, or skins where a straightforward controlled pulling, stretching, or rolling process is employed, which lifts the mechanical properties of DTD.363 and similar high-strength alloys by amounts ranging from 7.3 per cent to about 50 per cent. The third objection, that such treatment would leave the metal in a condition of dangerous internal stress, is overcome by applying the cold-work treatment after the solution heat treatment but before the precipitation heat treatment, snce the latter operation effectively relieves the internal stresses. Exceptions are noted in the recommendations with regard to applications where stiffness and fatigue are major factors.





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Aeroplane Geometry. Nils Lidbro. *Saab Sonics*, No. 9, January–March, 1950, pp. 19–23, illus.

Simplified explanation of the geometrical method of determining the shape of an air frame and its components by setting up tables of coordinates and body plans that replace all dimensioning of the constructional parts adjoining the surface of the skin. The method eliminates errors that occur when measuring or drawing points and curves under the graphic method. By marking on a special curve graph the coordinate values given in the tables, a clear picture is obtained of the number of points in the curve. Another advantage is that the geometrical reference drawing prepared under this system is free from the confusion of lines and figures necessary to indicate dimensions in the usual manner.

Producing a Prototype; Organization and Forethought to Reduce the Pre-Production Period to a Minimum. C. T. Wilkins. *Aircraft Production*, Vol. 12, No. 137, March, 1950, pp. 102–105, illus.

Fairey Aviation Company Envelope Jigging. *Shell Aviation News*, No. 139, January, 1950, pp. 22–24, illus.

Vickers-Supermarine Attacker. III—Fuselage Assembly, Mainplane Construction, Mainplane Subassemblies, Erection and Final Assembly. S. C. Poulsen. *Aircraft Production*, Vol. 12, No. 137, March, 1950, pp. 79–89, illus.

The Brabazon Prototype; A Survey of Some of the Fabrication and Assembly Methods. II—Inner Wing. *Sheet Metal Industries*, Vol. 27, No. 275, March, 1950, pp. 231–236, illus.

Stringer Machining; Simple Method Developed for Saro-Princess Extruded Sections. *Aircraft Production*, Vol. 12, No. 138, April, 1950, pp. 141, 142, illus.

Riveting as Applied to Aircraft Production. E. O. Baumgarten. *Automotive Industries*, Vol. 102, No. 6, March 15, 1950, pp. 176, 265, 266, 268, 270, 272, illus.

Wing Joint-Plates; Machining Difficult Fittings for the Airspeed Ambassador Mainplanes. *Aircraft Production*, Vol. 12, No. 138, April, 1950, pp. 113–119, illus.

Nimonic Alloys; Notes on the Annealing and Pickling of 75 and 75F and the Hot Working of 80 and 80A. *Aircraft Production*, Vol. 12, No. 137, March, 1950, pp. 77, 78.

A Survey of Modern Theory on Welding and Weldability. II. D. Seferian. *Sheet Metal Industries*, Vol. 27, No. 275, March, 1950, pp. 241–253, illus.

Cold Rolling Technique; The Application of Theory and Experiment to the Practice of Rolling. VI—Methods of Calculating Roll Force and Torque Based on Theories of Rolling. Hugh Ford. *Sheet Metal Industries*, Vol. 27, No. 275, March, 1950, pp. 197–202, 207, illus.

Notes on Machining Stainless Steel. R. H. King. *Aircraft Engineering*, Vol. 22, No. 252, February, 1950, pp. 55, 56.

Fixture Castings; Light-Alloy Units for Mainplane Assembly. *Aircraft Production*, Vol. 12, No. 137, March, 1950, p. 76, illus.

Electroforming Adapted to Aviation. Gilbert C. Close. *Aviation Operations*, Vol. 13, No. 2, February, 1950, pp. 31, 62, illus.

Étude Métallurgique de Quelques Points de Soudure sur Toles Vedal de 1 mm. d'Epaisseur. L. Pelletier. *La Recherche Aéronautique*, No. 10, July-August, 1949, pp. 25–30, illus.

Rubber-Die Forming; Development of the Marform Process by Glenn Martin. *Aircraft Production*, Vol. 12, No. 138, April, 1950, pp. 109–111, illus.

Stores Organization. II—Document-Control of Material Supplies and Movements. Richard Twelvetrees. *Aircraft Production*, Vol. 12, No. 137, March, 1950, pp. 90–94, illus.

Propellers (11)

The Scandia Propeller (Hydromatic 34D51). Tore Lindberg. *Saab Sonics*, No. 9, January–March, 1950, pp. 14–18, illus.

Quest for Efficiency; Work of the de Havilland Propeller Company's Development Establishment. C. B. Bailey-Watson. *Flight*, Vol. 57, No. 2151, March 16, 1950, pp. 346–351, illus.

Détermination et Calcul des Hélices d'Avions Optima, Simples et Coaxiales. I. II. Rene Hirsch. *France, Ministère de l'Air, Publications Scientifiques et Techniques, Nos. 220, 225*, 1948, 1949. 209; 133 pp.; illus. Service de Documentation et d'Information Technique de l'Aéronautique, Paris. 800, 750 Fr.

Research Facilities (50)

Serving the Air Future of the United States. Hugh L. Dryden. *Sperryscope*, Vol. 11, No. 12, Winter, 1950, pp. 6–9, illus.

Review of the operations of the National Advisory Committee for Aeronautics, describing its research laboratories, equipment, past achievements, responsibilities, and future objectives in technological leadership.

The Aeronautical Research Institute of Sweden. Hans G. Andersson. *Saab Sonics*, No. 9, January–March, 1950, pp. 2–5, illus. Description of the facilities, equipment, operations, and projected expansion of the establishment.

Quarterly Bulletin, Aeronautical Laboratories. *Canada, National Research Council, Report No. ME 1949* (4), October 1–December 31, 1949. 33 pp., illus.

Contents: Current Projects in Aerodynamics Laboratory, Aircraft and Allied Instrument Laboratory, Engine Laboratory, Flight Research Section, Gasoline and Oil Laboratory, Hydraulics Laboratory, Low Temperature Laboratory, Structures Laboratory, and Supersonics and Gas Dynamics Section.

The Peenemuende Rocket Center. I. Krafft A. Ehricke. *Rocketscience*, Vol. 4, No. 1, March, 1950, pp. 17–22, illus.

El Instituto Nacional de Técnica Aeronautica. Gregorio Millán Barbany. *Avión* (Madrid), Vol. 4, No. 42, August, 1949, pp. 323–326, illus.

Méthodes Françaises d'Essais Aérodynamiques Industriels. M. Jean Brocard and M. François Hussenot. *Technique et Science Aéronautiques*, No. 2, 1949, pp. 63–101, illus.

Sulla Ripresa Sperimentale Aeronautica in Italia. G. Pitaluga. *L'Ala* (Rome), Vol. 5, No. 16, August 15, 1949, pp. 9, 13, 24.

Rotating Wing Aircraft (34)

Tumble Bearing Transmissions in Helicopters. Paul Baumgartl. *American Helicopter*, Vol. 17, No. 3, February, 1950, pp. 6–8, 20, illus. 2 references.

Relazione de Esperienze su Rotori in Autorotazione. *L'Aerotecnica*, Vol. 28, No. 6, December 15, 1948, pp. 293–298, illus.

Sul Volo Verticale dell'Elicottero. M. Panetti. *L'Aerotecnica*, Vol. 28, No. 6, December 15, 1948, pp. 287–292.

"Top Sergeant" (American Helicopter Co. Pulse Jet). *Flight*, Vol. 57, No. 2152, March 23, 1950, p. 371, illus.

Britain's Flying Horse (Cierva Autogiro Co., Ltd.); Flight Impressions. *Canadian Aviation*, Vol. 23, No. 3, March, 1950, pp. 27, 42, illus.

XH-17 'Flying Crane' (Hughes). *Aviation Week*, Vol. 52, No. 14, April 3, 1950, p. 15, illus.

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French Helicopters. R. M. Garry. *The Aeroplane*, Vol. 78, No. 2022, March 10, 1950, pp. 288–292, illus.

Helicopter Development in France; Current Types Reviewed. R. M. Garry. *Flight*, Vol. 57, No. 2150, March 9, 1950, pp. 309–312, illus. (Extended summary of a paper.)

Using the Helicopter in Agriculture. Charles Kirchner, Jr. *Aviation Operations*, Vol. 13, No. 2, February, 1950, p. 26, illus.

The Future of the Helicopter in Canada. Douglas N. Kendall. *Aircraft and Airport*, Vol. 12, No. 3, March, 1950, pp. 9–11, illus.

Learning to Fly a Helicopter. John Fricker. *The Aeroplane*, Vol. 78, No. 2020, February 24, 1950, pp. 211–216, illus.

Static Longitudinal Stability and Control of a Convertible-Type Airplane as Affected by Articulated- and Rigid-Propeller Operation. Roy H. Lange and Huel C. McLemore. *U.S., N.A.C.A., Technical Note No. 2014*, February, 1950. 49 pp., illus. 3 references.

Sciences, General (33)

MATHEMATICS

The Characteristics of Systems Which are Nearly in a State of Neutral Static Stability. W. J. Duncan. *College of Aeronautics, Cranfield, England, Report No. 34*, January, 1950. 11 pp.

The rate of subsidence or divergence of a system that is nearly in a state of neutral static stability can be calculated easily from a knowledge of the mode of displacement in the neutral state. That mode is found by solving a set of linear algebraic equations. The first-order correction to the mode also can be found, and when the matrixes of inertia, damping, and stiffness are symmetrical, the mode correct to the first order can be made the basis of a calculation correct to the second order. For a continuous system with an infinite number of freedoms, the first-order approximation can be derived from the values of the potential energy, and the rate of dissipation of energy is an imaginary divergent motion proportional to the neutral mode and having a subsidence or divergence rate equal to unity.

A Note on Riemann's Method Applied to the Diffusion Equation. John W. Miles. *Quarterly of Applied Mathematics*, Vol. 8, No. 1, April, 1950, pp. 95–101, illus.

Introduction Technique au Calcul Matriciel et à Son Utilisation. W. Barrois, J. Simon-Suisse, and R. Basile. *La Recherche Aéronautique*, No. 6, November-December, 1948, pp. 3–14, illus. 4 references.

Sur la Recherche des Racines Réelles ou Complexes des Équations Algébriques. J. Simon-Suisse, Ch. Bourcier de Carbon, and R. Mazet. *La Recherche Aéronautique*, No. 5, September-October, 1948, pp. 53–61.

Sur les Méthodes de Calcul Employées pour la Recherche des Valeurs et Vecteurs Propres d'une Matrice. R. Weber. *La Recherche Aéronautique*, No. 10, July-August, 1949, pp. 57–60.

Un Critère de Stabilité pour les Equations Caractéristiques à Coefficients Réels ou Complexes. A. Hermann and J. M. Souriau. *La Recherche Aéronautique*, No. 9, May-June, 1949, pp. 19–23, illus. 2 references.

Derivative Bases. Philip Hartman and Aurel Wintner. *Tucuman, Argentina, Universidad, Facultad de Ciencias Exactas y Tecnologia, Revista*, Vol. 7, No. 1 (*Publicacion No. 499*), June, 1949, pp. 7–14. 3 references. (In English.)

Contributions to the Projective Theory of Curves in Space of Five Dimensions. Buchin Su. *Tucuman, Argentina, Universidad, Facultad de Ciencias Exactas y Tecnologia, Revista*, Vol. 7, No. 1 (*Publicacion No. 499*), June, 1949, pp. 15–79. (In English.)

New Metric-Theoretic Properties of Elliptic Space. L. M. Blumenthal and L. M. Kelly. *Tucuman, Argentina, Universidad, Facultad de Ciencias Exactas y Technologia, Revista*, Vol. 7, No. 1 (*Publicacion No. 499*), June, 1949, pp. 81–107. 5 references. (In English.)

Memoria Sobre La Resolucion de las Ecuaciones Differenciales Ordinarias de Primer Orden; Invariantes en Transformaciones de Contacto. Mario O. Gonzalez. *Tucuman, Argentina, Universidad, Facultad de Ciencias Exactas y Tecnologia, Revista*, Vol. 7, No. 1 (*Publicacion No. 499*), June, 1949, pp. 109–128.

Linear Simultaneous Equations. E. W. Parkes. *Aircraft Engineering*, Vol. 22, No. 252, February, 1950, pp. 48, 56, illus. Some practical aspects of their solution, the time required by a series, and the relative accuracy of the results.

The Normal Equations of the Method of Least Squares and Their Solution. M. Herzberger. *Quarterly of Applied Mathematics*, Vol. 7, No. 2, July, 1949, pp. 217–223. 10 references.

MECHANICS—VIBRATION

On Free Vibrations with Amplitudinal Limits. Aurel Wintner. *Quarterly of Applied Mathematics*, Vol. 8, No. 1, April, 1950, pp. 102–104. 2 references.

Harmoniques d'une Excitation Discontinue en Fonction du Rang et des Discontinuités; Réduction de Résonances, Amortissement par Vibrations Parasites Transverses. A. Fouche. *France, Ministère de l'Air, Publications Scientifiques et Techniques, Note Technique No. 29*, September, 1948. 38 pp., illus. Service de Documentation et d'Information Technique de l'Aéronautique, Paris. 170 Fr.

PHYSICS

On the Kinetic Theory of Rarefied Gases. Harold Grad. *Communications on Pure and Applied Mathematics*, Vol. 2, No. 4, December, 1949, pp. 331–407, illus. 11 references.

A discussion of the behavior of rarefied gases that consist of monoatomic molecules. Molecular chaos and binary collision are assumed. A sequence of approximations is introduced between the thermodynamic and the full use of the Boltzmann equation in order to obtain higher thermodynamic approximations that are required in the solution of physical problems. The distribution function of the physical system is expanded in Hermite polynomials, the coefficients of which are taken to be state variables. The number of coefficients taken determines the degree of approximation. The approximation involving stresses and heat flow as variables of state is shown to describe almost all flows that are encountered at present and to be better fitted to describe the slip flow region than the Burnett equations.

Lennard-Jones and Devonshire Equation of State of Compressed Gases and Liquids. R. J. Buehler, R. H. Wentorf, Jr., J. O. Hirschfelder, and C. F. Curtiss. *University of Wisconsin, Naval Research Laboratory, Department of Chemistry, CM-565 (NOrd 9938, Task Wis-1-C)*, February 3, 1950. 28 pp., illus. 2 references.

The reduced equation of state for compressed gases and liquids was computed according to the theory of J. E. Lennard-Jones and A. F. Devonshire for a large number of temperatures and volumes, and the corrections due to gas imperfections of internal energy, specific heat, and entropy were evaluated. Comparisons of experiment with theory for nitrogen and argon show that the Lennard-Jones and Devonshire equation is unsatisfactory at densities near the critical point, but at higher densities it can be used.

The Equation of State for Rigid Spheres. R. J. Buehler, R. H. Wentorf, Jr., J. O. Hirschfelder, and C. F. Curtiss. *University of Wisconsin, Naval Research Laboratory, Department of Chemistry, CM-587 (NOrd 9938, Task Wis-1-C)*, February 14, 1950. 22 pp., illus. 1 reference.

The Lennard-Jones and Devonshire equation, which yields good results for gases at high densities, is extended to densities below the critical value by developing an exact free-volume method. The resulting equation has the proper asymptotic behavior at high and low densities and passes smoothly through the intermediate region. The development indicates what difficulties might arise in generalizing the Lennard-Jones and Devonshire equation to low densities.

The Diffraction of a Plane Wave Through a Grating. John W. Miles. *Quarterly of Applied Mathematics*, Vol. 7, No. 1, April, 1949, pp. 45–64, illus. 16 references.

Space Travel

Exhaust Velocity. Hermann Oberth. (*Wege zur Raumschiffahrt*, Part 2, Chapter 5, pp. 23–36.) *Rocketscience*, Vol. 4, No. 1, March, 1950, pp. 2–5. 2 references.

Structures (7)

Strength of Aeroplanes in Relation to Repeated Loads. D. Williams. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 4, February, 1950, pp. 291–304, illus. 5 references.

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A review of the ability of aircraft structures to withstand the effects of repeated loads, outlining the statistical methods by which the load frequencies can be estimated. Repeated applications of very heavy loads amounting to approximately half of the ultimate load, produced by exceptionally rough air conditions or by violent evasive action, are not likely to present serious problems, since tests have shown that current design factors are adequate. Smaller loads averaging less than 50 per cent of ultimate, also are well within present design standards, barring radically poor provision against fatigue. Oscillating stresses produced by resonance vibration arising from engine or propeller forces are potentially dangerous because they are likely to be superimposed on existing locked-up stresses, but they can be overcome by avoiding stress concentrations and by providing adequate insulation of the engine from the air frame. Jet engines will reduce that risk because of their lack of vibration.

Aircraft Wing Weight Estimation. J. F. Carreyette. *Aircraft Engineering*, Vol. 22, No. 251, January, 1950, pp. 8–11, illus.

Six empirical formulas for wing-weight prediction, using one to ten variables, were tested by computation and comparison with completed structures. Statistical analysis of the deviations led to the abandonment of four of the methods. The remaining methods, based on the span and the gross weight, respectively, give accuracy factors of 12.1 and 12.2 per cent. A "first approximation" method derived from studies of the same wing forms resulted in a set of curves from which figures could be obtained with an accuracy factor of about $7^1/_2$ per cent.

L'Impostazione dei Problemi delle Strutture Aeronautiche sulla Base de Risultati Sperimentali. L. Lazzarino. *L'Aerotecnica*, Vol. 29, No. 5, October 15, 1948, pp. 256–259. 24 references.

A Recurrence Matrix Solution for the Dynamic Response of Aircraft in Gusts. John C. Houbolt. *U.S., N.A.C.A., Technical Note No. 2060*, March, 1950. 90 pp., illus. 6 references.

Le Flutter a un Degré de Liberté en Régime Supersonique. R. Weber and W. Ruppel. *La Recherche Aéronautique*, No. 10, July-August, 1949, p. 31, illus.

Flexural Vibrations of the Walls of Thin Cylindrical Shells Having Freely Supported Ends. R. N. Arnold and G. B. Warburton. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 197, No. 1049, June 7, 1949, pp. 238–256, illus. 4 references.

Experimental investigation showed that the complexity of the mode of vibration of thin cylindrical shells bears little relation to the natural frequency. Cylinders of small thickness-diameter ratio, with length about equal to or less than the diameter, may have their higher frequencies associated with the simpler modes of vibration. The frequency equation that is derived by the energy method is based on strain relations given by Timoshenko. The displacement equations are comparable to those of Love and Flugge. Results obtained for cylinders of various lengths, each of the same thickness-diameter ratio, and for a thin cylinder in which the simpler modes of vibration occur in the higher frequency range, show that there are three possible natural frequencies for a particular nodal pattern, two of which normally occur beyond the aural range.

A Note on Collapsing Cylindrical Shells. Theodore E. Sterne. *Journal of Applied Physics*, Vol. 21, No. 2, February, 1950, pp. 73, 74, illus. 1 reference.

Expressions are obtained for the instantaneous dependence of pressure upon radius within a collapsing cylindrical shell of incompressible liquid when subjected to (a) neither external nor internal pressure or to (b) an external pressure but no internal pressure. Dynamical considerations suggest that high pressures and radial velocities should be reached.

The Analysis of Structures Consisting of Curved Members of Variable Section. B. Saravanos. *Aircraft Engineering*, Vol. 22, No. 251, January, 1950, pp. 24, 25, illus.

The modifications involved in the application of the Hardy-Cross moment distribution method as used for straight uniform-section members.

The Diffusion of Loads in Non-Rigid Circular Frames. S. R. Lewis. *College of Aeronautics, Cranfield, England, Report No. 33*, February, 1950, 23 pp., illus. 1 reference.

Extending the work of W. J. Goodey, numerical examples are given of the shear distribution around a frame subjected to a single concentrated radial load for variations in the parameters such as frame stiffness, skin thickness, and stringer spacing. The case considered is that of a long cylinder with a closed end or where the portion aft of the loaded frame has a restraining effect upon the forward section. The parameters chosen are those common to aircraft design, making it possible to obtain a reasonably accurate shear distribution around a frame by the use of data supplied, without making the actual shear calculation. The appendix gives the method of obtaining the shear load due to a tangential load and moment from the radial load expressions.

The Behaviour of Continuous Stanchions. J. F. Baker, M. R. Horne, and J. W. Roderick. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 198, No. 1055, September 7, 1950, pp. 493–509, illus. 5 references.

Exceeding the Buckling Limit in Thin Plates. G. Schnadel. *U.S., Navy, The David W. Taylor Model Basin, Translation No. 64*, December, 1949. 11 pp., illus. 10 references.

Stress and Strain Concentration at a Circular Hole in an Infinite Plate. Elbridge Z. Stowell. *U.S., N.A.C.A., Technical Note No. 2073*, April, 1950. 14 pp., illus. 2 references.

On Reissner's Theory of Bending of Elastic Plates. A. E. Green. *Quarterly of Applied Mathematics*, Vol. 7, No. 2, July, 1949, pp. 223–228. 4 references.

Minimum Weight of Stiffened Cylindrical Shells in Pure Bending. W. R. Micks. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, pp. 211–216, illus. 2 references.

Impact Stresses in Systems of Bars. I. II. Boris N. Cole. *The Engineer*, Vol. 189, Nos. 4910, 4911, March 3, 10, 1950, pp. 264–266; 288–290; illus.

On the Compression of a Short Cylinder Between Rough End-Blocks. F. Edelman. *Quarterly of Applied Mathematics*, Vol. 7, No. 3, October, 1949, pp. 334–337. 2 references.

Integrally Stiffened Structures. Paul Sandorff and G. W. Papen. *Aeronautical Engineering Review*, Vol. 9, No. 2, February, 1950, pp. 30–38, illus. 3 references.

The Equivalent Loading Method and the Equivalent Beam Method. Pei-Ping Chen. *Quarterly of Applied Mathematics*, Vol. 7, No. 2, July, 1949, pp. 183–200, illus. 3 references.

A Note on the Bending Moment Induced in the Booms of a Spar at the Point of Application of a Concentrated Load. H. F. Winny. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part IV, February, 1950, pp. 281–290, illus.

A concentrated load, such as occurs in a wing spar at the fuselage, causes a discontinuity in shear strain of the spar web, which induces a bending moment in the booms through the medium of the rivets (or bolts) that attach the booms to the web. A mathematical theory is developed which shows that this bending induced in the boom is of a damped wave form starting at the point of application of the shear, and in practice, the magnitude of the stresses produced by the bending moment may be appreciable at the wing root when the boom is deep compared with the spar depth.

Sweepback Effect on Box Beam Stresses. *Aviation Week*, Vol. 52, No. 14, April 3, 1950, pp. 20–22, illus. 5 references.

Analysis and Design of Stiffened Shear Webs. Paul H. Denke. *Journal of the Aeronautical Sciences*, Vol. 17, No. 4, April, 1950, pp. 217–231, illus. 10 references.

Buckling of Flat Plywood Plates in Compression, Shear, or Combined Compression and Shear; Buckling Tests of Flat Plywood Plates in Compression with Face Grain 45° to Load—Loaded Edges Clamped, Others Simply Supported. L. A. Ringelstetter. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1316-J (Supplement)*, February, 1949. 14 pp., illus.

Feuille de Travail. II—Détermination des Dimensions Optima des Plaques-Sandwichs. W. Flügge. *La Recherche Aéronautique*, No. 7, January-February, 1949, pp. 43–45, illus. 2 references.

Fifteen Types of Mechanical Joints for Tubing. *Product Engineering*, Vol. 21, No. 3, March, 1950, pp. 142, 143, illus.

Scales for Airplanes. William H. Gottlieb. *Aviation Operations*, Vol. 13, No. 2, February, 1950, pp. 32, 67, 68, illus., diagr.

Details of the aircraft-weighing mechanism built for the Wright-Patterson Air Force Base at Dayton, O., which is capable of weighing airplanes ranging from 1,020 to 350,000 lbs. and can be calibrated to record weights up to 800,000 lbs.

Appareil de Pesée pour Avions. G. Raguenet. *La Recherche Aéronautique*, No. 7, January-February, 1949, pp. 41, 42.

Complementary Minimum Principles for an Elastic-Plastic Material. H. J. Greenberg. *Quarterly of Applied Mathematics*, Vol. 7, No. 1, April, 1949, pp. 85–95. 9 references.

A mathematical investigation of the mechanical behavior of bodies that consist of an isotropic, inviscid, elastic-plastic material that obeys the stress-strain law of Prandtl and Reuss, has a

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sharply defined yield point, and does not exhibit work hardening. Two minimum principles are derived for the mixed boundary problem where the velocities are given on part of the surface and the rates of change of the surface stresses on the remainder.

A New Theory of Plastic Flow. D. Trifan. *Quarterly of Applied Mathematics*, Vol. 7, No. 2, July, 1949, pp. 201–211, illus. 9 references.

A mathematical theory of plastic flow for an isotropic, incompressible, strain-hardening material that exhibits a gradual transition from the elastic to the plastic state. The stress-strain relations give the rate of change of the stress tensor explicitly in terms of the strain tensor, the rate of change of the strain tensor, and the strain invariants.

Some Implications of Work Hardening and Ideal Plasticity. D. C. Drucker. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 411–418, illus. 4 references.

The usual basic assumptions of the theory of plasticity when coupled with a mathematical formulation of the concepts of work hardening and ideal plasticity require stress-strain relations to be of the Mises-Prager form $d\epsilon_{ij}^{p} = \lambda(\partial f/\partial\sigma_{ij})$. For a work hardening material, $\lambda = G(\partial f/\partial\sigma_{kl})d\sigma_{kl}$. G and f may depend upon stress, plastic strain, and the history of plastic strain.

Elastic Equilibrium in the Presence of Permanent Set. G. Colonnetti. *Quarterly of Applied Mathematics*, Vol. 7, No. 4, January, 1950, pp. 353–362.

An Elastic Theory of Dislocations. Elizabeth H. Mann. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 199, No. 1058, November 7, 1949, pp. 376–394, illus. 8 references.

A theory that describes the internal stresses set up by slip processes in crystalline materials assumes that only the three stress components that act across the surface in an elastic body need be continuous at that surface. These conditions admit a general type of dislocation with arbitrary elastic discontinuities of displacement. If the slip bands in a deformed crystal are replaced by the appropriate dislocations, the stresses in the remaining elastic region may be calculated by this theory.

Variational Principles in the Theory of Finite Plastic Deformations. Aris Phillips. *Quarterly of Applied Mathematics*, Vol. 7, No. 1, April, 1949, pp. 110–114.

L'Effet de Flèche Appliqué aux Aérodynes. R. M. Conrad. *La Recherche Aéronautique*, No. 5, September-October, 1948, pp. 3–14, illus. 31 references.

A Note on the Principle of Uniqueness. H. Roberts. *Aircraft Engineering*, Vol. 22, No. 251, January, 1950, p. 20, illus. The use of the principle to simplify stress analysis where some members are unloaded.

A Statistical Representation of Fatigue Failures in Solids. W. Weibull. (*Kungliga Tekniska Högskol, Handlingar Nr. 27*, 1949.) *Acta Polytechnica (Stockholm), No. 49 (Mechanical Engineering Series, Vol. 1, No. 9)*, 1949. 50 pp., illus. 11 references. (In English.) Sw. Kr. 4.

The relations between the probability of the failure of a specimen of material, the load applied as defined by the range of stress applied during a cycle, and the number of load cycles, give a complete description of the phenomenon of fatigue. The relations also provide the means for determining the influence of the dimensions of the specimen. Statistical methods are evolved, with the aid of punched-card calculating machines, by which estimates may be made of the probability that a specimen will endure a certain number of cycles of a given load.

La Fatigue des Métaux; Son Importance dans la Construction Aéronautique. M. R. Cazaud. *Technique et Science Aéronautiques*, No. 3, 1949, pp. 147–159, illus.

Thermodynamics (18)

Contributions to the Thermodynamic Functions by a Planck-Einstein Oscillator in One Degree of Freedom. Herrick L. Johnston, Lydia Savedoff, and Jack Belzer. *U.S., Navy, Office of Naval Research, No. NAVEXOS P-646*, July, 1949. 159 pp., illus. 7 references. U.S. Govt. Printing Office, Washington. $0.60.

To meet the demand for a table of Planck-Einstein oscillator contributions with smaller intervals in the argument and with the newest values of the physical constants, the Planck-Einstein functions have been recomputed at 0.001-unit intervals of the ν/T argument up to ν/T 3.000, and at 0.01-unit intervals of the argument up to ν/T 10.42, using Birge's latest values of the physical constants, together with certain recommendations of the National Bureau of Standards. Another table that is independent of the particular choice of physical constants and, hence, may be adapted to future values of the physical constants uses the argument $x = hc\nu/KT$ and tabulates the computed values of the functions in terms of the gas constant R as a unit. The tables include the argument, the four thermodynamic functions, and their first differences.

The Effect of Diffusion of the Main Reactants on Flame Speeds in Gases. J. Corner. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 198, No. 1054, August 22, 1949, pp. 388–405, illus. 21 references.

The general equations of a single-reaction flame are written to allow for the diffusion of the main reactants and products. Since the pressure-dependence of the flame speed is not altered by diffusion, the expression gives an easily applied solution for the speed of a flame maintained by a single reaction whose rate depends only on the temperature and the concentrations of reactants.

The Mathematics of Elementary Thermodynamics. Karl Menger. *American Journal of Physics*, Vol. 18, No. 2, February, 1950, pp. 89–103.

The Structure of the Reaction Zone in a Flame. S. F. Boys and J. Corner. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 197, No. 1048, May 11, 1949, pp. 90–106. 3 references.

The structure of one-dimensional flames can be completely determined by the constants of heat conductivity, diffusion, and homogeneous reaction rates. Although the most general case is mathematically intractible when diffusion is neglected compared with heat conductivity, those cases in which the reaction rates are either unimolecular or bimolecular, or the quasibimolecular form of a unimolecular reaction at low pressures, can be solved by the method of successive approximations with an error in the order of only 10 per cent.

Solution of Steady State Temperature Problems with the Aid of a Generalized Fourier Convolution. A. W. Jacobson. *Quarterly of Applied Mathematics*, Vol. 7, No. 3, October, 1949, pp. 293–302. 3 references.

The Dynamics of the Combustion Products Behind Plane and Spherical Detonation Fronts in Explosives. Geoffrey Taylor. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 200, No. 1061, January 6, 1950, pp. 235–247, illus. 8 references.

The Theoretical Solution of the Propagation of Nitric Oxide Decomposition Flames. M. J. Henkel, W. P. Spaulding, P. W. Knaplund, and G. Vandervort. *University of Wisconsin, Naval Research Laboratory, Department of Chemistry, CM-564 (NOrd 9938, Task Wis-1-D)*, January 30, 1950. 51 pp., illus. 10 references.

The theory of propagation of one-dimensional steady-state flames is applied to the nitric oxide reaction. An idealized form of that reaction makes a generalization of the usual hydrodynamical equations of change applicable to all flame phenomena, including steady-state flames, ignition, and detonation. The effects of diffusion and of chemical reaction are studied in order that an estimate can be made of the relative importance of those parameters in determining the flame velocity. The effect of ambient temperature, heat transfer from the flame to the flame holder, and thermal conductivity is also estimated. The computations indicate that a considerable change in diffusion does not alter the results appreciably, although it does appear that the flame thickness is closely related to the diffusion coefficient and varies directly with it.

Gaseous Detonations. I—Stationary Waves in Hydrogen-Oxygen Mixtures. II—Initiation by Shock Waves. Donald J. Berets, Edward F. Greene, and G. B. Kistiakowsky. *American Chemical Society, Journal*, Vol. 72, No. 3, March, 1950, pp. 1080–1091, illus.

Convection Forcée de la Chaleur en Régime Laminaire, à la Surface d'un Corps de Revolution. M. Vasseur. *La Recherche Aéronautique*, No. 5, September-October, 1948, pp. 65–69, illus.

An Investigation of Aircraft Heaters. XXXIII—Experimental Determination of Thermal and Hydrodynamical Behavior of Air Flowing Along Finned Plates. L. M. K. Boelter, R. Leasure, F. E. Romie, V. D. Sanders, W. R. Elswick, and G. Young. *U.S., N.A.C.A., Technical Note No. 2072*, March, 1950. 68 pp., illus. 9 references.

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Water-Borne Aircraft (21)

A Comparison of Theoretical and Experimental Wing Bending Moments During Seaplane Landings. Kenneth F. Merten, Hose L. Rodriguez, and Edgar B. Beck. *U.S., N.A.C.A., Technical Note No. 2063*, April, 1950, 36 pp., illus. 21 references.

The Restricted Future of Flying-Boats. E. P. Johnson. *The Aeroplane*, Vol. 78, No. 2023, March 17, 1950, pp. 320–322, illus.

Wind Tunnels (17)

Détermination de la Corde Maximum d'une Maquette pour Soufflerie et de la Vitesse de Référence. P. Guienne. *La Recherche Aéronautique*, No. 5, September-October, 1948, pp. 31–34, illus. 2 references.

Diffuseurs Courts pour Souffleries. J. Lacaine. *La Recherche Aéronautique*, No. 7, January-February, 1949, pp. 35–42, illus. 2 references.

Soufflerie Sonique de l'Institut de Mécanique des Fluides de Lille. G. Gontier. *La Recherche Aéronautique*, No. 10, July-August, 1949, pp. 3–9, illus. 6 references.

Standardizing the Shorthand of Aeronautics

(*Continued from page 30*)

or Pr, such as N_{Eu} or N_{Pr}. No difficulty is then encountered if these quantities are used as factors in mathematical expressions, and their designations become true symbols rather than mere abbreviations unsuitable for mathematical combination.

The complexity of the general field of aeronautics is widely recognized. Workers in the field are drawn from all of the various branches of the applied physical sciences. Even the biological sciences are being called upon to aid in the solution of certain of the specialized problems of flight in which the characteristics of the human anatomy impose limitations beyond which improvements in the mechanical performance of the aircraft are of no avail. It is extremely important in a field of such complexity that a common language be employed which is intelligible to all. To achieve the adoption and maintenance of such a common language, it is inevitable that some compromises will be found necessary. It is remarkable that so few will be required by those who follow the present standard in the preparation of manuscripts for publication. The slight inconvenience that may occasionally arise in using the approved symbols will be many times offset by the ease with which future readers of the published article will be able to follow the text without constant reference to a table defining unfamiliar symbols.

Propulsion Analysis for Long-Range Transport Airplanes

(*Continued from page 15*)

choice of the type of power plant to be used could, of course, only be made after detailed study of the economics of each case, together with relative reliability and other service problems proper to each type of power plant. From a purely engineering point of view, however, a definite conclusion can be drawn.

As we strive for greater speeds coupled with long range and in the presence of ever increasing competition, it appears that the reciprocating engine no longer offers an adequate solution. Its range drops rapidly after 400 m.p.h. The choice is, therefore, between the turboprop and the pure jet. The turboprop power plant at altitudes from 30,000 to 40,000 ft. offers any range between 2,500 and 4,500 miles at speeds of from 450 to 500 m.p.h. The pure jet at altitudes from 20,000 to 40,000 ft. covers the range between 1,500 to 2,000 miles at speeds from 550 to 580 m.p.h. For nonstop transoceanic and transcontinental flights the turboprop is, therefore, the answer. For shorter runs of 2,000 miles, or below, the pure jet gives considerably higher speed.

To obtain greater range with the pure jet, an amount of fuel considerably in excess of that assumed would be necessary, which would automatically lead to a much larger airplane. Pure jets are, therefore, confined to high-speed, relatively low-range flight until such time as engines with much more efficient fuel consumption are available. One more point appears evident from this analysis: Unless jet transports are flown at speeds of from 550 to 580 m.p.h., their use is unjustified, because for lower speeds approximately the same results could be obtained with the turboprop with considerably less fuel expenditure. The aerodynamic design of the pure jet airplane must, therefore, be the most advanced, and it would be an error to build a jet-propelled transport airplane of conventional design with straight wings.

The sudden burst of air transport activities in England, where turboprop and pure jet transports are about to be put into service, makes it necessary for our industry to face the challenge. If we are to keep our air supremacy over the seven seas, it is imperative that the industry start without any loss of time to develop turboprop transport planes for fast, long-range service and pure jet transports for shorter ranges at still higher speeds.

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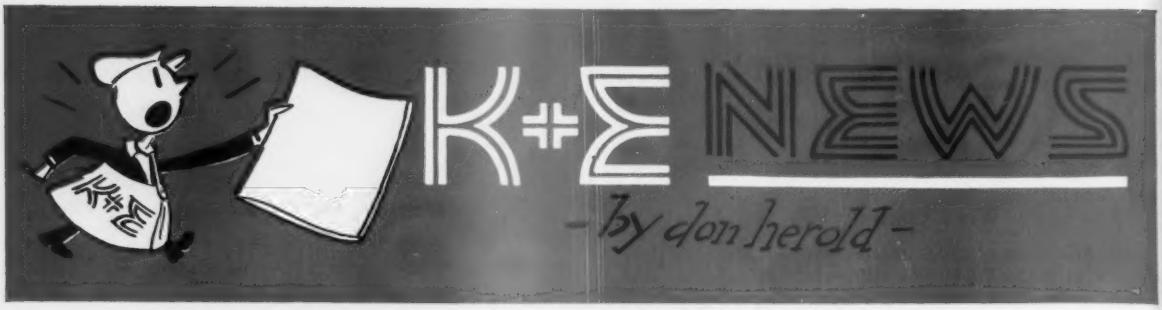

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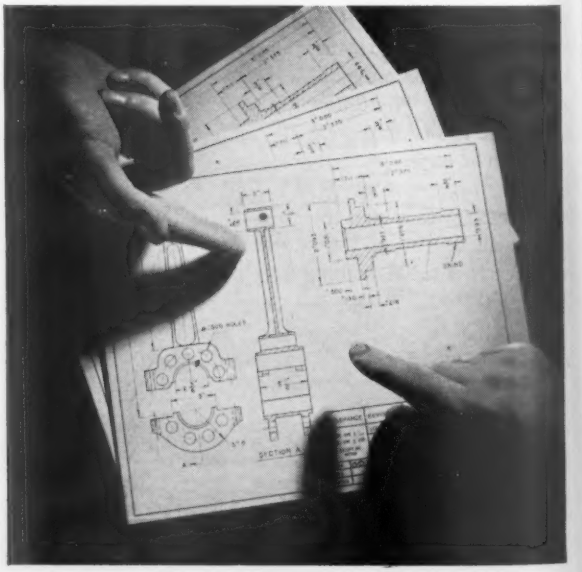

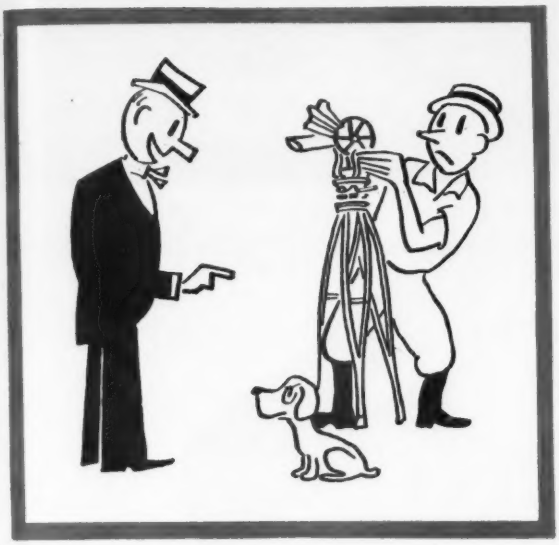

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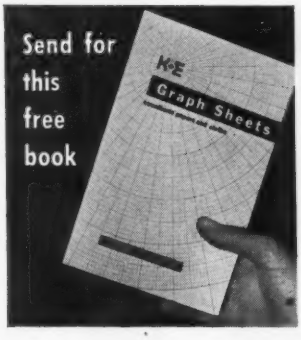

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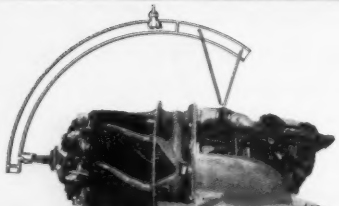

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Aeronautical Reviews

Books

Development of Aircraft Engines and Fuels

By Robert Schlaifer and S. D. Heron. Boston, Harvard University, Graduate School of Business Administration, 1950. 754 pp. $5.75.

Tremendous strides have been made in the development of aircraft and aircraft engines within the past 30 years. Those who were not intimately connected with this highly specialized art may be inclined to see only the overall results and to overlook the many and costly failures that stand as milestones marking the road to success. Inasmuch as development has necessarily been sponsored largely by governments that sought improved performance of their military airplanes, the Harvard Business School assigned to Dr. Robert Schlaifer and to S. D. Heron, a consulting engineer, the task of preparing this book, which is described as "two studies of relations between government and business." The role of government, however, is not the sole subject of the work.

The book reviews the contracting techniques and the history of reciprocating engine and gas turbine development in the United States, Great Britain, and Germany and analyzes the factors that contributed to the success or failure of each major project. From these analyses has been evolved a reasonably simple set of rules for evaluating the risks in any new project. The book should have important value as a reference for those engaged in setting up programs for development and procurement of airplane power plants and their accessories.

The book is divided into two sections. The first, comprising more than two-thirds of it, is devoted to engines and is written by Dr. Schlaifer. Mr. Heron's section deals with fuels. Each section is complementary to the other in the sense that fuel and engine development are closely related, but the basis of compilation is different, and no related conclusions between the two sections are drawn.

Most of those who have been engaged in, or who have been familiar with, development work in the aircraft engine field will agree with many of the conclusions drawn. Some of these are summarized below.

(1) Only private firms, highly efficient and highly experienced, can be expected successfully to cope with the rapid advances in the complex and highly specialized field of airplane engine development.

(2) If too long a time is taken in the development of a new engine, the effort will probably be wasted.

(3) It is improbable that a new firm will succeed in developing a usable aircraft power plant unless it can arrange to obtain the experience of quantity production at an early date.

(4) A private firm has greater incentive to succeed than a governmental organization. The former must maintain a proper balance in the direction of its development programs or it will probably fail; governmental establishments tend to become a collection of specialists each promoting his own specialty, with the result that prime objectives often are neglected.

(5) Although the military services are capable of evaluating equipment and doing valuable research on problems for which private firms have no facilities, they are, in general, incapable of developing such a complex finished product as an airplane engine.

(6) The practice in the American military establishments of filling executive posts, even in such engineering organizations as Wright-Patterson Air Force Base or the Naval Aircraft Factory, with military officers on short tours of duty is enough to ensure that these organizations will have ineffective administration, whatever the ability of the officers may be.

To those familiar with developments in the aircraft field the book will be of great interest for its historical value, because for the first time there is here presented a complete and accurate picture of 25 years of development. Those presently engaged in developmental work will find much material that should help them avoid the errors and miscalculations of the American, British, and German development programs and procurement methods which logically reduce to a common denominator.

P. B. TAYLOR
Sanderson & Porter

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Theoretical Hydrodynamics

By L. M. Milne-Thomson. 2nd Ed. New York, The Macmillan Company, 1950. 600 pp., diagrs. $8.50.

This is a second, and extensively revised, edition of the 1938 *Theoretical Hydrodynamics* by the Professor of Mathematics in the Royal Naval College, Greenwich. It is a more comprehensive text than his *Theorectical Aerodynamics* that I reviewed last year. The Hydrodynamics necessarily has some things in common with the Aerodynamics and likewise assumes previous mathematical training only through the elements of the calculus.

Theoretical Hydrodynamics is a comprehensive text giving an exposition and development of the mathematical-physical theory of fluid motion for application either to hydro- or aerodynamics. Professor Milne-Thomson departs from the traditional presentation of the subject by basing his treatment consistently throughout on vector methods and notation with their natural consequence in two dimensions, the complex variable. Vector treatment is not of itself a novelty, but I think this is the first comprehensive text in English making exclusive use of vector methods.

Vectors are viewed without reference to any system of coordinates, and vector operations are deduced by operational methods that lead directly to the classical theorems. The general properties of fluid motion are studied in the clear light of vector formulation. This gives a physical insight into phenomena that are usually unnecessarily obscured by their description in a particular coordinate system. Reduction to algebraic form is left for the final step preparatory to computation or quantitative evaluation.

The wealth of exercises at the end of each chapter, gleaned from years of teaching, as well as from the examinations of many other well-known English hydrodynamicists, will be especially helpful to teachers of the subject, whether or not they adopt this book as their text. The author

refers to Lamb's *Hydrodynamics* as a more complete reference, yet in most cases the author's treatment is adequate and much more readable than Lamb's. This may be, in part, because of the uncrowded and better organized presentation of the material in Milne-Thomson.

In this book, Milne-Thomson introduces the necessary mathematics at the right place, much better than he did in *Theoretical Aerodynamics*, where he left the chapter on vectors for the last. Here, instead, a complete treatment of vectors, vector operations, and vector theorems is given in Chapter II, following an introductory chapter on the elements of fluid mechanics. Then, throughout the remainder of the book the basic equations can be derived and manipulated by the unqualified use of vectors, resulting in a concise and understandable treatment.

In Chapter V, for example, he introduces just the mathematics needed at that point. In Chapter IV, he had developed the equations of two-dimensional flow, with the concept of stream function and velocity potential. Chapter V introduces complex variables and a firmly packed treatment of functions of the complex variable, including the fundamentals of mapping. With this mathematical foundation, Chapters VI through XIV proceed smoothly into two-dimensional motion covering streaming motions, airfoils, sources and sinks, moving cylinders, the mapping theorems of Schwarz and Christoffel, jets and currents, cavitation, vortices, and surface waves. Chapters XV through XVIII consider three-dimensional motion. Chapter XIX deals with the effects of viscosity in fluid mechanics.

Chapter XX, "Subsonic and Supersonic Flow," is a new chapter and the major change in the Second Edition. It is designed to introduce the main problems of compressible aerodynamics to those who have digested the earlier chapters. I think it succeeds in this limited objective. However, Chapter XX does not stand by itself; it naturally leans heavily on the material in earlier parts of the book.

In Chapter XX, I like the clear and concise exposition of the needed thermodynamic concepts and relations. So often textbooks on compressible aerodynamics make hash of this. Following this section, the equations are developed for inviscid, nonheat conducting, nonradiating, compressible flow involving the stream function. Then follows a brief analysis of two-dimensional flow, including the hodograph method, convergent-divergent nozzle flow, characteristics, expansion round a corner, and shock waves.

I wish Milne-Thomson would expand and extend this chapter on compressible aerodynamics into many chapters, including suitable exercises and would change the name of his book to *Theoretical Hydrodynamics and Aerodynamics*. We might then have the first acceptable text for a graduate course at the professional level.

J. C. HUNSAKER
Department of Aeronautical Engineering, Massachusetts Institute of Technology

Elements of Aerodynamics of Supersonic Flows

By Antonio Ferri. New York, The Macmillan Company, 1949. 434 pp., illus. $10.

The field of supersonic aerodynamics has advanced at such a great pace that the textbooks in vogue even three years ago are no longer adequate. The problems then formulated have since been solved and documented by the scientists of Europe and America, with the works of the former enjoying no widespread translation or publication in the English language. The definitive volume on supersonic flow has yet to appear. However, even at this early stage of development, *Elements of Aerodynamics of Supersonic Flows* by Dr. Antonio Ferri has missed greatness by only an eyelash!

The author, now chief of the Gas Dynamics Section at Langley Air Force Base, is a rare combination of theorist and experimentalist, qualified by an outstanding record of research and teaching. By summarizing the cream of scientific investigations done both here and abroad, he has fashioned an eleventh-hour report that will strongly appeal to research engineers and advanced graduate students. Much of the material has never appeared in textbooks. Its presentation allows wide opportunity for application in a variety of high-speed design problems.

In the preface, Dr. Ferri states that he will consider the aerodynamics of purely supersonic flow in an elementary manner. The incongruity of this statement soon becomes apparent after the first chapter, when the reader is immediately plunged into the two-dimensional domain. Realizing, then, that previous knowledge of the bases of supersonics is assumed, the true worth of the text may be evaluated.

Whereas most texts studiously avoid two- and three-dimensional phenomena, Ferri has chosen to divide his text by this classification. The first half of the book is distinguished by the beautiful step-by-step development of the method of characteristics. Commencing with the potential equations, the concept of characteristic lines is clearly introduced. Then, going into the hodograph plane, the epicyclic and shock polar diagrams are derived and their use demonstrated. Although difficult to follow, the complete Busemann nozzle analysis is faithfully reproduced while numerical examples help toward fuller understanding.

Noteworthy also is the analytic discussion on rotational flow behind curved shocks and the long chapter on supersonic profiles. Here, following a concise presentation of the Ackeret theory, all practical shapes are treated quantitatively and experiment is shown to corroborate theory closely. Even the supersonic biplane is covered. This excellent section could lead to successful results in supersonic axial flow cascade design. Though strictly qualitative, the treatise on physical measurements contains a storehouse of knowledge gleaned by the author in his work as director of the supersonic wind tunnel at Guidonia, Italy.

To include three-dimensional considerations in a text represents a radical departure from stereotyped predecessors; to include such a complete, thorough picture means a saving of many research hours. Once the existence of a potential is justified, the perturbation equations are derived in suitable coordinate systems. Using the method of potential theory and spherical harmonics, proper source, sink and doublet distributions are indicated for bodies of revolution, yawed configurations, duct flows, etc., the work of Tsien and Ferrari being exploited. These paragraphs will serve as an excellent introduction to this subject material.

Conical bodies are next studied. After consideration of the conical shock polar (apple curve), the characteristic system for three dimensions is investigated. Returning to airfoils, Ferri shows the changes of source distribution and intensity evinced by finite wings, completing his analysis by extending the Prandtl lifting line theory to supersonic flows, thus leading to the determination of lift and drag for various plan forms and sections.

The remainder of the book contains an informative bibliography and tables to be used in conjunction with the shock polar and characteristic diagrams included. In particular, the Prandtl-Meyer expansion table covers a range of Mach Numbers up to $M = 4$ by steps of 0.01.

All authors must somewhere draw the line. Ferri has chosen to give us only a smattering of the vital problems of interaction of shock with boundary layer, and of accelerated and time-dependent flows. Transonic and hypersonic flow are not touched upon. To some, these omissions will appear as serious limitations.

Likewise, the readability of the text leaves something to be desired, and the make-up is not always logical. However, the abundance of hitherto elusive literature, presented with a minimum of high-powered mathematics and complemented by invaluable numerical examples, charts, tables, experimental comparisons, and the liberal use of illustrative diagrams,

easily prevails over these superficial objections.

As intimated, the first chapter of only 18 pages is an inadequate preparation for the work that follows. This is unfortunate, for, by the inclusion of detailed one-dimensional fundamentals, the author could have introduced the supersonic realm to a wealth of neophyte readers. Academically, it appears that a preliminary course is required before "Elements" can be applied. But, on the basis of the scope of the subject material alone, one must concede that here is a new work of vast importance!

ROBERT F. BRODSKY
Instructor of Mechanical Engineering
New York University

Nonlinear Vibrations in Mechanical and Electrical Systems

By J. J. Stoker. New York, Interscience Publishers, Inc., 1950. 273 pp., figs. $5.00.

The task of reviewing the fourth book on the same subject within 18 months could be a tedious one. Not so, however, when the work is so refreshingly practical as is Professor Stoker's. *Nonlinear Vibrations* is exactly the type of text which will appeal to the engineer who, today, must struggle with so many nonlinear phenomena produced by noncooperative nature.

While the volume is devoted exclusively to nonlinear vibration, Professor Stoker's introduction states: "Practically all of the problems in mechanics are nonlinear from the outset and the linearization commonly practiced is an approximating device which is often a confession of defeat in the face of the challenge presented by the nonlinear problem as such." How true! It often happens that the inexperienced engineer assumes by habit that linearization is always permissible and suddenly finds that his conclusions, because of true nonlinearity, are far removed from physical realities.

Most of the books on nonlinear mechanics published to date were

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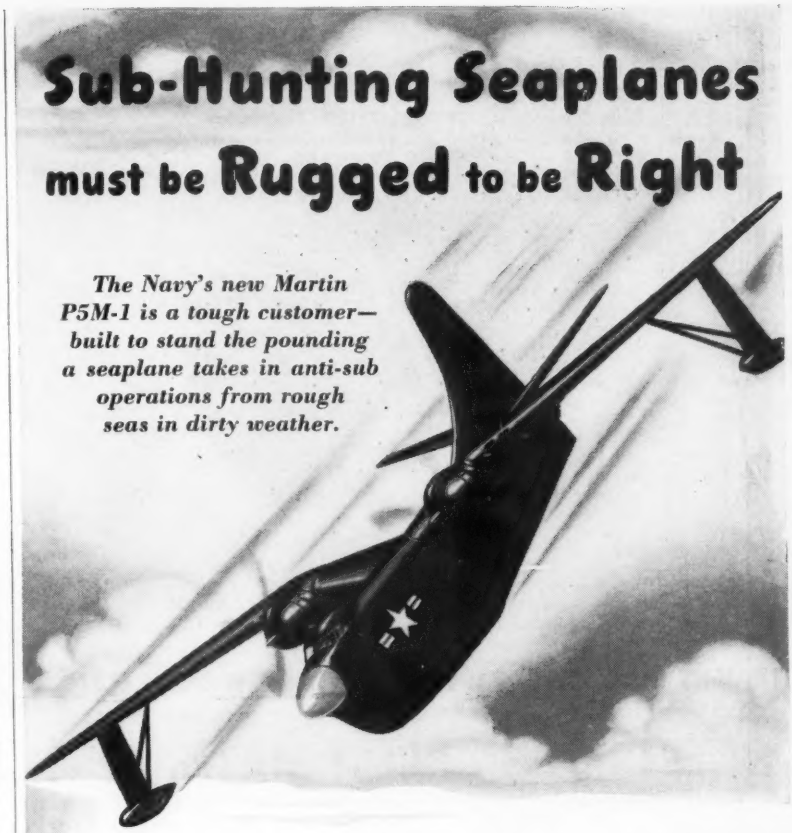
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written for mathematicians and not for engineers. Professor Stoker fills in the gap and writes primarily for engineers, and he wisely divides the book into two parts. Part I (Chapters I–VI) deals with the engineering aspects of nonlinear vibrations; Part II (six appendices) deals with the rigorous proofs of some of the theories. While Part I can be understood by anyone who has studied differential equations and infinite series, one should not undertake to study Part II without a firm foundation in operational calculus.

Chapter I, consisting of only eleven pages, is an abridgement of the theories involved in linear vibrations and will serve to familiarize the reader with the literature and the notations used.

Chapter II is devoted primarily to free vibrations of undamped systems with nonlinear restoring forces, using the excellent example of the pendulum, which, taken rigorously, is not a linear problem at all. Several other examples are given, and the writing is so clear and so free of ambiguity that the chapter gives one not only a mathematical grasp of nonlinear problems, but a sense of their physical meaning.

Chapter III describes free oscillations with damping and the geometry of integral curves. The author explains the graphical methods of Liénards and Meissner which, in most cases, are amply accurate for the engineer. He also treats a number of mechanical and electrical problems.

Chapter IV deals with forced oscillations of systems with nonlinear restoring force. The important phenomenon for servo system designers, that of hunting, is excellently presented, and the chapter ends with a striking confrontation in the form of a concise table showing the characteristics and properties of linear, as contrasted with, nonlinear systems. To a practicing engineer, this table alone is worth the price of the book.

Chapter V concerns itself with self-sustained oscillations that are often called self-excited. Such systems are common in nature, in particular, in electronic work. The author treats also the relaxation oscillations and gives several fine examples of these phenomena. The remainder of the chapter is devoted to the review of different analytical ways of attack with particular attention to methods other than that originated by van der Pol.

The final Chapter, VI, takes the reader back to linear oscillations, but in contrast to Chapter I, in the motions studied here the parameter of time is not a constant. The author then describes the Hill equation and discusses a few mechanical and electrical problems leading to this equation. A detailed analysis of stable and unstable parameter values is also given.

The balance of the book consists of six appendices that are of particular interest to the teacher of

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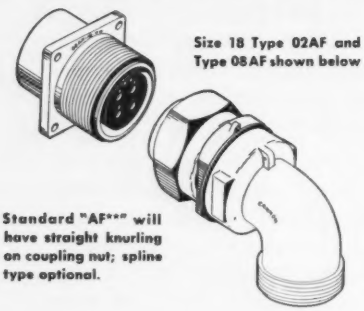

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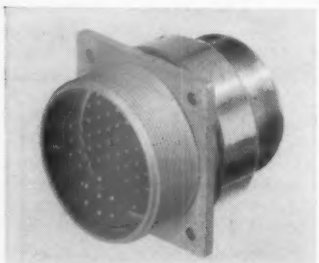

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mathematics. Being an engineer, this reviewer emphasized the engineering aspects of the book. A mathematical reviewer would doubtless have given a less detailed account of the first six chapters and a thorough review of the six appendices that exemplify the same excellent writing technique and depth of analysis. These are their titles: (1) Mathematical Justification of the Perturbation Method, (2) The Existence of Combination Oscillations, (3) The Existence of Limit Cycles in Free Oscillations of Self-Sustained Systems, (4) Relaxation Oscillations of the van der Pol Equation, (5) The Criterion of Poincaré for Orbital Stability, and (6) The Uniqueness of a Limit Cycle in the Free Oscillations of a Self-Sustained System.

While the book is extremely practical, its value could have been made still greater if the author had included some remarks on the different types of electromechanical computers that have been designed to solve nonlinear problems. Interest in them among engineers is great, and one could not find a better qualified person than Dr. Stoker for the explanation of how and why such machines work. It would also have been of interest to the aeronautical engineer to have in this treatise, instead of so many electrical examples, one or two taken from pure aerodynamics, or, perhaps, aerodynamical ballistics—e.g., methods of solving equations of guided missile trajectories that, in many cases, are vibratory and of nonlinear character. It would also be of advantage for the inquisitive student to have the bibliography extended beyond the references cited in text. Professor Stoker drew on 42 references, but the number of publications available on the subject exceeds 100. These remarks are not intended to detract in the slightest from the value of this excellent text, which is particularly recommended to engineers specializing in control, stability, and instrumentation of the airplane.

DR. STEPHEN J. ZAND
Vice-President
in Charge of Engineering
Lord Manufacturing Company

Book Notes

AIRPLANE DESIGN

The Observer's Book of Aircraft. Joseph Lawrence. New Edition. London and New York, Frederick Warne & Company, Ltd., 1949. 248 pp., illus. $1.25.

This new edition of a book last issued in 1945 describes 109 types of aircraft flying today, arranged according to their configurations. For example, all multijet powered monoplanes are found on pages 86 through 95, and all low-wing monoplanes powered by four piston engines on pages 144 through 163. A flight photograph, a three-view silhouette, and brief descriptive data are given for each aircraft. British and American types predominate, with some types from European countries.

EDUCATION AND TRAINING

An Introduction to the Engineering Profession. John G. McGuire and Howard W. Barlow. Cambridge, Mass., Addison-Wesley Press, Inc., 1950. 207 pp., figs. $3.50.

The greater part of this book is concerned with the eleven major fields of engineering as vocations. A brief history and an occupational summary listing the principal jobs and their definitions and a brief bibliography of books and visual aids is given for each field of engineering. There is a preliminary section on the profession of engineering. The two final chapters deal with supporting studies such as mathematics, engineering drawing, the humanities and the social sciences, chemistry, and physics. The final section of 64 pages deals with engineering problems on the slide rule and logarithms and in mechanics and the eleven engineering fields discussed elsewhere in the book. The authors are, respectively, a professor of engineering drawing and dean of engineering at the Agricultural and Mechanical College of Texas.

ELECTRICAL EQUIPMENT

Electrical Machinery; a Practical Study Course on Installation, Operation and Maintenance. F. A. Annett. 3rd Ed. New York, McGraw-Hill Book Company, Inc., 1950. 458 pp., figs. $3.75.

In this new edition of a book last revised in 1938, chapters on the fundamentals of electronics and on electron tubes and their applications have been replaced by four new chapters on Electrons and Electron Tubes, Electronic Rectifiers, D-C-Motor Speed Control, and Flame-Failure Protection and Smoke-Density Indicators. These cover the principal advances in electron tubes and their applications in the field covered by the book and the fundamentals of tubes and their circuits. Other sections of the book follow the plan of previous editions, covering the installation, operation, and maintenance of electrical machinery, including the fundamentals of magnetism, properties of magnets, electric circuits, electrical instruments, meters, and the application of principles to dynamoelectric machinery. The author is associate editor of the magazine *Power*.

ELECTRONICS

Advances in Electronics. Vol. II. Edited by L. Marton. New York, Academic Press, Inc., 1950. 378 pp., illus. $7.60.

Contents: Cathode Ray Tube Progress in the Past Decade with Special Reference to Manufacture and Design, Hilary Moss; Electron Lenses, P. Grivet; Field Plotting and Ray Tracing in Electron Optics; A Review of Numerical Methods, G. Liebmann; Cathodoluminescence, G. F. J. Garlick; Intrinsic Dielectric Breakdown in Solids, H. Frolich and J. H. Simpson; The Microwave Magnetron, Gunnar Hok; Ferromagnetic Phenomena at Microwave Frequencies, George T. Rado; and Microwave Spectroscopy, Donald K. Coles.

Electron-Tube Circuits. Samuel Seely. New York, McGraw-Hill Book Company, Inc., 1950. 529 pp., figs. $6.00.

The author's purpose in this textbook is to develop a clear analytical method in the study of electron-tube circuits, to present and study the types of circuit having widespread application, and to show with examples the procedures in combining various types of circuits to achieve simple and complicated operations. The fundamental properties of electron tubes and their basic circuit applications are reviewed, and the discussion proceeds into a variety of untuned amplifiers, including voltage, video and power amplifiers, electronic computing circuits, and circuits using the electron tube as a switch. Tuned circuits are next taken up, including power rectifiers, filters, and regulators. Radar applications of circuits developed during the war are discussed in the later chapters. The author is a professor of electrical engineering at Syracuse University.

Pulses and Transients in Communication Circuits, an Introduction to Network Transient Analysis for Television and Radar Engineers. Colin Cherry. New York, Dover Publications, Inc., 1950. 317 pp., figs. $3.95.

This introduction to circuit transient analysis is designed for television and radar engineers. It was originally published in London in 1949. The emphasis is on rigorous physical arguments, only elementary mathematics being used, and electric wave forms, rather than analytical functions, are dealt with. Bibliographies at the ends of chapters include about 200 references to articles and books. The author is a lecturer at the Imperial College, University of London.

Matrix Analysis of Electric Networks. P. LeCorbeiller. Cambridge, Mass., Harvard University Press and New York, John Wiley & Sons, Inc., 1950. 112 pp., figs. $3.00.

The purpose of this monograph is to present for engineers a simple approach to Gabriel Kron's method of analysis of stationary electric networks, using the same tensor equation for each conceivable type of machine. Except for two equations originating in topology which are proved in mathematical textbooks, all formulas used, including a derivation of Kron's mesh-method formulas, are given complete proofs by the author. Only the necessary level of mathematics is used. A review of matrix algebra is presented in Chapter I. The author is professor of general education and applied physics at Harvard University.

MACHINE DESIGN

Elementary Engineering Design. H. A. Morgan. London, Macdonald & Company, 1950. 164 pp., charts. 15s.

This book is intended for the new draftsman wishing to study design principles. The first 109 pages cover twelve designs, from the knuckle joint to the centrifugal clutch coupling, chosen as reasonably difficult typical designs illustrating such principles as torsional theory and bending moment theory to design. Calculations are emphasized in the treatment of each design. A separate section of 38 pages deals with miscellaneous exercises on pure torsion, combined bending and twisting, bending, and combined bending and direct stress. Ten useful tables are included as appendixes. The author is a lecturer in machine drawing and design at the Northampton Polytechnic in London.

MANAGEMENT AND FINANCE

Engineering Economic Analysis. Clarence E. Bullinger. 2nd Ed. New York, McGraw-Hill Book Company, Inc., 1950. 397 pp., diagrs. $4.00.

In this new edition of an engineering textbook first published in 1942, the material has been rearranged and revisions have been made in the text. Minimum Cost Analysis is now treated in a separate chapter, apart from the usual profit form of analysis, and material on various ways of handling bond issues has been added to the chapter on The Financial Analysis. The original purpose, to enable the young engineer to report on the economic solution of an engineering project, corollary to the technical solution, is retained. A bibliography of about 95 books, brought up to date, is included. The author is head of the Department of Industrial Engineering at the Pennsylvania State College.

MATERIALS

A.S.T.M. Standards on Adhesives. Philadelphia, American Society for Testing Materials, 1950. pp. 787–845. $1.25.

This compilation contains the 15 A.S.T.M. standards on adhesives, including test methods for the resistance of adhesive bonds to chemical

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agents, tensile properties, stripping strength, strength properties of adhesives in shear by compression loading, strength properties of adhesives in plywood type construction in shear by tension loading and new tests on impact strength, strength properties of metal-to-metal adhesives in shear by tension loading, and cleavage strength of metal-to-metal adhesives. Definitions of terms relating to adhesives are included.

OPERATING PROBLEMS

Air Whaler. John Grierson. London, Sampson Low, Marston & Company; New York, MacDonald & Company, 1949. 243 pp., illus. $4.00.

A whaling expedition to the Antarctic is described in which Supermarine Walrus biplane amphibians were used successfully for air reconnaissance in spotting whales and directing surface crews. The airplanes were used also for ice and weather reconnaissance, and in scientific and geographical exploration, discovering three 1,500-ft. peaks east of the Shackelton Ice Barrier besides surveying the northeast corner of the Barrier itself. The author concludes that the airplane has as much value in whaling for its ability to furnish information on ice and meteorological conditions, and on rival whaling ships, as in the spotting of whales and the direction of catcher crews. Its wider use would cause revolutionary changes in the disposition of catcher vessels, and the use of the helicopter with modern armament might eliminate both the catcher vessel and the harpoon gun in whaling.

POWER PLANTS, ROCKET

Kleine Raketenkunde. Hans K. Kaiser. Stuttgart, Mundus Verlag, 1949. 150 pp., illus. RM 9.

A history of rockets is covered from the earliest times, with emphasis on European work from 1920 to the present time, including German developments during World War II. Recent work in the United States on rockets, rocket engines, and supersonic airplanes is discussed, and the entire field of reaction propulsion is discussed in the latter part of the book, including a review of the possibilities of space travel. A bibliography of about 25 books and journals is included and a glossary of about 65 rocket terms.

PRODUCTION

Machine Tools for Engineers. Charles R. Hine. New York, McGraw-Hill Book Company, Inc., 1950. 355 pp., figs. $3.50.

Designed for the engineering student, this book covers the subject of metal forming by cutting, emphasizing the production and engineering point of view rather than the development of skill. The principal machine tools and operations are covered, including for each tool an analysis of work performed, its principal parts, its various types and attachments, and its limitations. Bibliographies are given at the ends of chapters. The author is assistant professor of manufacturing processes at the Rensselaer Polytechnic Institute.

Layout Planning Techniques. John R. Immer. New York, McGraw-Hill Book Company, Inc., 1950. 430 pp., figs. $5.00.

The purpose of this book is to present the basic principles of production flow and layout and methods for the solution of layout problems, illustrated by techniques in successful use in industry. Applications to factory planning, offices, merchandising, and to the aircraft and other specific industries are discussed. The principles of assembly-line layout and methods of presentation of the layout occupy the greater part of the book, with a final section on materials handling. There is a section of selected case studies, and suggested standards and general rules are given in appendixes, with a bibliography of about 200 articles and books, arranged according to chapters, and a list of about 50 films. The author is assistant professor of industrial management in the School of Business Administration at the University of Minnesota.

REFERENCE LITERATURE

Statistical Handbook of Civil Aviation. (U.S. Civil Aeronautics Administration. Office of Aviation Information.) Washington, U.S. Govt. Printing Office, 1949. 127 pp. $0.50.

This new edition covers available statistics through June, 1949, on airports, Federal airways, aircraft and airmen certifications, pilot training, production and exports, civil flying, scheduled air-carrier operations, and accidents. Federal airway data have been revised to include instrument landing system (ILS) approaches, and radio range station figures now show the number of low- and medium-frequency and the number of high-frequency stations. Monthly as well as annual figures are given in this edition on the more significant traffic categories.

RESEARCH FACILITIES

Engineering College Research Council. Proceedings of the Annual Meeting, 1949. Iowa City, State University of Iowa, College of Engineering, 1950. 137 pp. $2.00.

In addition to annual reports of officers of the Engineering College Research Council, this volume contains 13 technical papers on instrumentation in engineering research, four on military interests in basic and applied research, and six on engineering research conducted by nonmilitary Federal Government agencies.

Partial contents: Instrument Engineering—Its Growth and Its Promise, G. S. Brown, D. P. Campbell, and H. T. Marcy; The Development and Use of the Conju-Gage for Gear Inspection, A. R. Fultz; Polar Vector Indicator, E. A. Walker; A New Technique for Photo-Elastic Stress Analysis, Gilbert Smiley; A Versatile Null-Balance Optical Bridge, C. M. Albright, Jr.; Electron Diffraction, M. J. Columbe; The SUI Polyphase Oscilloscope and Some of Its Derivatives, E. B. Kurtz; Slope Measuring Device, R. L. Harvin; The A-C Visualizer and New Oscillograph Developments, C. H. Schermerhorn; Research with a Network Analyzer, J. D. Ryder; Thermopile Heat and Wave Meters, E. D. Howe; Magnetic Amplifiers, Ernst Weber; U.S. Air Force Interests in Technical Education and in Basic and Applied Research, Col. L. I. Davis; Scientific Research, Future Naval Power, and National Security, T. J. Killian; and the N.A.C.A. Research Program in Scientific and Educational Institutions, T. L. K. Smull.

ROTATING WING AIRCRAFT

American Helicopter Society. Proceedings of the Fifth Annual Forum, 1949. New York, Institute of the Aeronautical Sciences, Inc., 1950. Various paging, illus. $3.00 to members; $5.00 to nonmembers.

Contents: Performance Characteristics of a Combined Rotary Wing and Fixed Wing System, Kurt H. Hohenemser; Jet Propelled Rotor for Helicopters, Joseph S. Yasecko; Flight Testing of Helicopters by the U.S. Navy, John W. Mazur; Design and Construction of the Cornell Fiberglas Helicopter Main Rotor Blades, Harold Hirsch; Helicopter Flight Test Technique Variable Blade Stiffness Program, H. Weichsel, Jr.; An Analysis of the Pressure Jet Helicopter, L. L. Douglas; Development of Metal Blades, A Simplified Dynamic Stress Analysis of Hinged Rotor Blades, Robert Mayne and Wm. C. Johnson, Jr.; Miscellaneous Flight Characteristics of the Model 47 Helicopter, T. J. Harriman; Properties of Case Hardened Steel Surfaces; Effect of Grinding and Method of Detection and Prevention of Defective Areas, Lawrence E. Follis; and Punch Card Computing Techniques and Their Applications to Rotary Wing Aircraft Problems, Frank L. Stulen.

First Convertible Aircraft Congress, sponsored by the Philadelphia Sections of the American Helicopter Society and the Institute of the Aeronautical Sciences. New York, Institute of the Aeronautical Sciences, Inc., 1950. 114 pp. $3.00 to members; $5.00 to nonmembers.

Contents: Higher Flight Speeds for Rotary Wing Aircraft by Combination with Fixed Wing, K. Hohenemser; Semi-Rigid Rotors for Convertible Aircraft, Glidden Doman; Design Studies of Various Tilting Fuselage Convertible Aircraft, Lloyd Leonard; A New Approach to Convertibility, Anton Flettner; Performance and Stability of a Convertible Aircraft, Charles Zimmerman; The Development of the Convertoplane, Gerard P. Herrick; Naval Uses for Convertible Aircraft, William Knapp; Will the Convertible Aircraft Break the Bonds of the Present Restricted Market for Private Aircraft?, Roland Rohlfs; Configurations of Convertible Aircraft, Louis de Monge de Franeau; and Conversion from Propeller to Lifting Rotor Operation After Power Failure, Robert L. Lichten.

STRUCTURES

Stress and Strength of Manufactured Parts. Charles Lipson, G. C. Noll, and L. S. Clock. New York, McGraw-Hill Book Company, Inc., 1950. 259 pp., charts, figs. $4.50.

This volume is intended for designers, engineers, and metallurgists concerned with the stress, strength, and the prevention of failures of parts and assemblies. The solution is considered to achieve a proper balance between the stress imposed by service loads, assembly and fabrication conditions, and the strength of the material from which the part was made. Knowledge of both stress and strength is therefore essential, and the first part of the book deals with general principles underlying the basic concepts of the balance between stress and strength. The greater part of the book (179 pages) consists of charts of geometric and fatigue stress concentration factors and allowable stresses for infinite and for limited life. The materials dealt with are annealed and quenched and drawn steels. Supplementary notes on the charts, a bibliography of 270 references, and an index of authors cited are included.

SCIENCES, GENERAL

MATHEMATICS

Analysis and Design of Experiments; Analysis of Variance and Analysis of Variance Designs. H. B. Mann. New York, Dover Publications, Inc., 1949. 198 pp. $2.95.

The author's aim in this book is to present a systematic design of experiments with a view to their statistical analysis for mathematicians. The emphasis is on rigorous mathematical treatment, including proofs and derivations of formulas and the principles of statistical inference. The book is designed for upper class students majoring in mathematics and for the mathematician who has no statistical background. Among the subjects covered are matrices, quadratic forms, multivariate distribution, Galois fields, and incomplete balanced block designs. The author is a professor of mathematics at the Ohio State University.

Tables of the Generalized Exponential-Integral Functions. (Harvard University. Computation Laboratory, Annals, Vol. XXI.) Cambridge, Mass., Harvard University Press, 1949. 416 pp. $8.00.

These tables were compiled at the request of the U.S. Air Force and the Atomic Energy Commission, continuing work begun with tabulations of generalized sine- and cosine-integral functions (*Annals of the Computation Laboratory, Vols. XVIII and XIX*). The functions are tabulated to six decimal places in eight tables of 50 pages each, ordered by ascending h, and each table of 50 pages ordered by ascending a. Introductory pages discuss interpolation in the tables and applications that include problems in electromagnetics, hydrodynamics, the theory of sound, and the theory of elasticity.

Tables of the Function sin ϕ/ϕ and of Its First Eleven Derivatives. (Harvard University. Computation Laboratory, Annals, Vol. XXII.) Cambridge, Mass., Harvard University Press, 1949. 241 pp. $8.00.

This compilation was undertaken, at the request of the U.S. Air Force, to fill the need for more extensive tables of the function sin ϕ/ϕ. Nine-decimal-place tables of the function are given at intervals of one-half degree, with a range of ten revolutions, and the scope is extended to its first eleven derivatives. Values of ϕ from 0 to 20π radians are given. Applications of the Fourier transform techniques expedited by these tables include analysis of directive antennas, radiation patterns from the normal modes of rectangular membranes, normal modes of a rectangular waveguide or horn in the case of electromagnetic waves, and other problems involving expansions in Fourier series, Taylor's series, series of Legendre polynomials, and series of Tchebychet polynomials.

Tables of the Bessel Functions of the First Kind of Orders Sixty-Four Through Seventy-Eight. (Harvard University. Computation Laboratory, Annals, Vol. XIII.) Cambridge, Mass., Harvard University Press, 1949. 566 pp. $8.00.

This volume, continuing computations begun at the request of the U.S. Navy Bureau of Ordnance and continued at the request of the U.S. Air Force and Atomic Energy Commission, is the eleventh in a series of tables of Bessel functions. As in previous volumes, the tables are carried to ten decimal places.

An Index of Nomograms. Douglas P. Adams. New York, John Wiley & Sons, for the Technology Press, 1950. 174 pp. $4.00.

About 1,700 nomograms in 21 technical fields are indexed. An alphabetical index by subjects precedes the main classified list, which includes such fields as mathematics, physics, aeronautics, electronics, machine design, machine tools, welding and sheet metal, and metals. About 95 trade journals are indexed for the years from 1923 to about 1946, with references appearing in some subjects for 1947 and 1948. This index makes possible the quick location of alignment charts in widely scattered sources and should be useful in all technical libraries. The author is associate professor of graphics at the Massachusetts Institute of Technology.

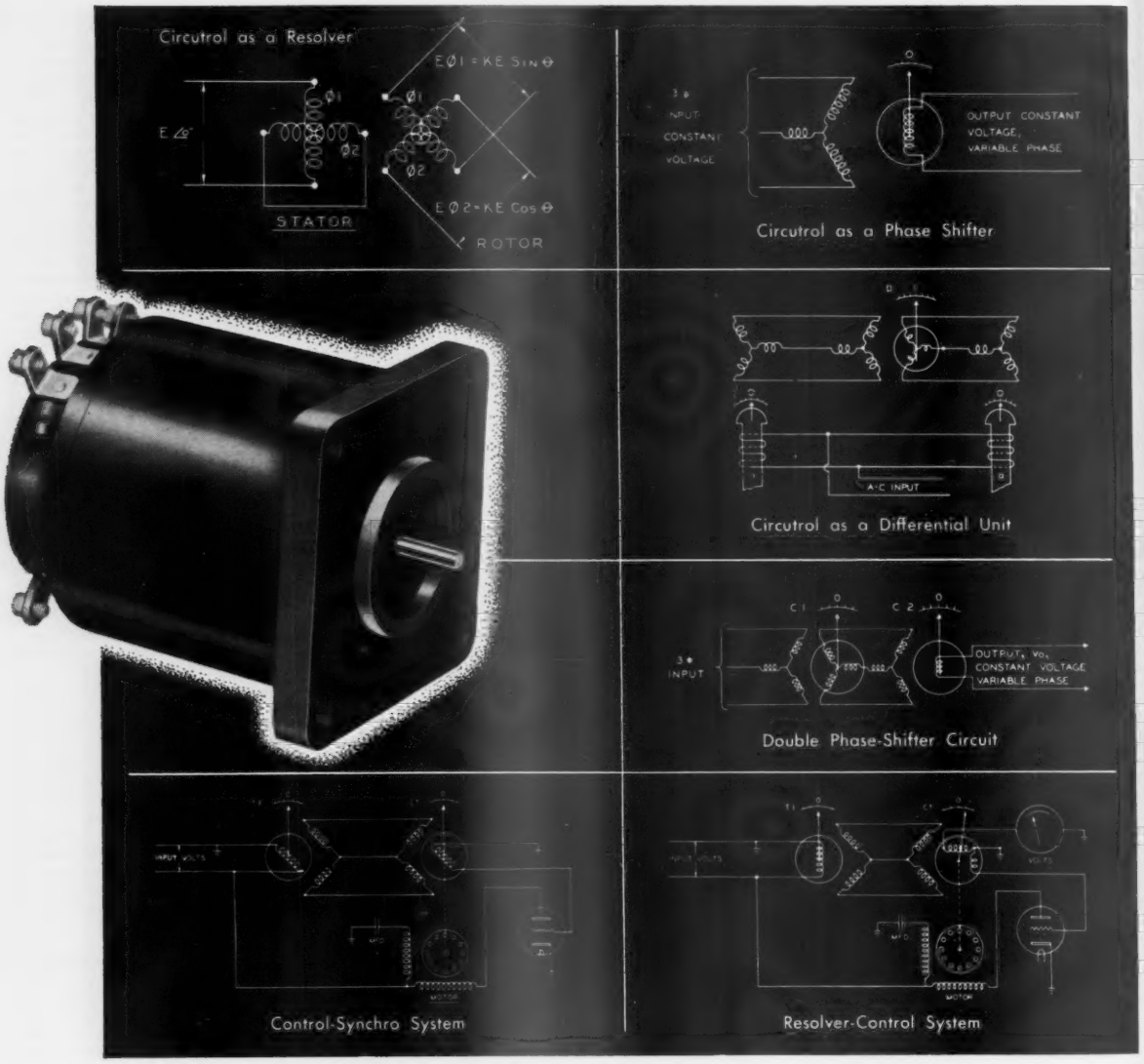
Numerical Solutions of Differential Equations. H. Levy and E. A. Baggott. New York, Dover Publications, Inc., 1950. 238 pp. $3.00.

This is a reprint of *Numerical Studies in Differential Equations*, published in London in 1934. The actual solution of ordinary differential equations and the numerical examination of many of their properties are the basis for the discussion, omitting the determination of characteristic numbers and the investigation of orthogonal properties. Graphical integration and graphical methods for detailed solution are first discussed, then numerical solution over a limited range and forward integration of first-order equations. Final chapters deal with simultaneous equations and equations of the second and higher orders, and special methods applicable to linear differential equations of the second order.

THERMODYNAMICS

Thermodynamics, Principles and Applications to Engineering. Ernst Schmidt. Authorized translation from the 3rd German Edition, by J. Kestin. London and New York, Oxford University Press, 1949. 532 pp., diagrs. $7.00.

Dr. Schmidt, writing from Farnborough, England, states that this is more than a translation, as many changes have been made to adapt the book to English and American usage. A chapter on jet and rocket propulsion has been added, and the discussions of compressible fluid flow and of gas and steam turbines have been extended to include up-to-date methods. Numerical tables and calculations include the most recent data available. A bibliography of 54 books cited, published from 1887 to 1948, is included, and footnote references are included throughout. The third German edition was published in 1945.



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Corporate Member News

(*Continued from page 9*)

units to companies requiring metal forming but not in a great enough volume to justify the purchase of units. (See article in April REVIEW, pages 50–52.)

• Recorder Pens . . . Ballpoint pens have been made standard accessories for the single- and two-record pen-dragging electronic strip-chart instruments manufactured by **Brown Instrument Division, Minneapolis-Honeywell Regulator Company.** The pens have quick-drying nonsmudging characteristics that make them suitable for records where lines are closely spaced, and they are recommended when measurements demand rapid movements of the pen across the chart.

• U.S.–Hawaii Air Express . . . Air-express service between all cities in the United States and Honolulu has been inaugurated by **Northwest Airlines** and Railway Express Agency. This extension of service gives shippers direct air and rail connections with Northwest Airlines' Stratocruisers, which make the 2,700-mile overwater flight from the Seattle-Tacoma international airport in 8 hours. From Minneapolis-St. Paul, shipments can reach Honolulu in 15 hours; from New York, in 21 hours. Shipments are handled as an extension of the domestic air-express system and may be sent prepaid or collect. C.O.D. service is also available on such shipments.

• Standardized Seating . . . **Pan American World Airways** is standardizing its fleet of 30 DC-4 Clippers serving Latin America into three types of seating arrangements for greater passenger comfort and more efficient operation. Ten of the DC-4's are equipped with Sleeperette seats and have a capacity of 30 persons. They are assigned to long-distance routes. Seven of the aircraft accommodate 44 passengers in two rows of reclining double-seats. The remaining DC-4's, equipped with 61 seats, will be assigned to P.A.A.'s low-cost tourist Clipper service. Interiors of the tourist Clippers are being remodeled, and galleys are being reinstalled in the aft part of the main cabin.

• Exercises Option . . . **Republic Aviation Corporation** has notified the U.S. Government of its intention to purchase all leased premises—buildings and land—not now owned by the company at its Farmingdale, L.I., location. The buildings comprise well over 1,000,000 sq.ft. of floor space, and the property includes the airport and hangar facilities. Property is expected to pass over to Republic ownership early this summer . . . Net income for 1949 was $876,632 after provision for Federal and N.Y. State taxes. Sales for the year were $47,722,195, and backlog on December 31 was $36,983,000. Retooling for newer production models of the F-84 Thunderjet, changing engineering requirements, additional expenses for company-sponsored research and development, and lower allowable percentage of profit of A.F. contracts contributed to the difficulty of earning a higher return on 1949 sales. Net income in 1948 was $2,196,475 on sales of $49,816,896. Condition of the company continued to improve during 1949. Cash balance increased substantially, and cash and receivables at the year's end were more than double total current liabilities.

• Three-Dimensional Copying . . . A machine for the reproduction of three-dimensional surfaces to any desired scale has been developed by **A. V. Roe Canada Limited,** primarily in connection with the manufacture of gas-turbine blades. A master pattern larger than the article to be duplicated is employed. By virtue of its large size, this master can be made with considerable accuracy and finish; as a result, the forging dies, reproduction masters, and like objects that are made with this reduction process have negligible dimensional errors and surface irregularities. The machine now in use has a reduction ratio of 10 to 1. The machine consists of a master table and a work table connected by a pantograph linkage that governs the scale of reproduction. An overhead reduction lever carries a tracer wheel at its outer end and a ratio-related cutting medium, such as a grinding wheel, toward its fulcrum end. The master pattern, usually made of plaster, is caused to move in two planes so that the tracer wheel contacts the entire surface during its passage, while, simultaneously, the workpiece is being moved in a like manner except that distance in accord with the ratio prescribed by the pantograph. The third dimension, or rise and fall, is transmitted from the tracer wheel to the cutter or grinding wheel by the medium of the overhead lever. Patent rights for the machine have been assigned to Canadian Patents and Development Limited of Ottawa.

• J-47 Parts Contract . . . A $1,000,000 extension of its contracts with General Electric Company for additional quantities of the jet-engine parts that **Ryan Aeronautical Company** has been manufacturing for the past 2 years has been received. On the basis of the new orders, Ryan production of parts for the General Electric J-47 jet engine is assured until August, 1951. The stainless-steel exhaust cones and other parts are shipped to Lockland, Ohio, for final assembly at the factory that G-E has taken over especially for J-47 production.

• 1949 Report . . . **Square D Company** ended the fiscal year 1949 with a net profit of $3,149,162 on net sales of $35,177,817, as compared with net earnings of $3,736,-012 in 1948 on net sales of $40,224,029. Rising labor costs caused a disproportionate decline in earnings, and economics in other phases of the operation were more than offset by these rising costs. During the year, inventories were reduced, working capital was increased, and the balance outstanding on a 5-year bank credit agreement arranged in 1947 was reduced. Capital expenditures were principally for the purchase of new machinery and equipment, with a view toward increasing production and reducing costs. Activities of the Kollsman Instrument Division increased; the backlog of orders for aircraft products is greater, and the company looks forward to an increasing volume of sales in this division.

• Thompson Granted Patents . . . Patents on Refrasil, a lightweight high-temperature insulation material, have been granted to the **H. I. Thompson Company,** thermal and acoustical insulation engineers and manufacturers. Refrasil, which will withstand sustained temperatures up to 1,800°F. and flash temperatures up to 2,400°F., was originally developed for use in conventional reciprocating engined aircraft. It is now also produced in preformed foil encased blankets, boots, and covers, as well as in batt, tape, and fabric for use in jet tail-cone and tailpipe installations.

• New District Office . . . **Tinnerman Products, Inc.,** manufacturers of Speed Nut fasteners, has opened a district office in St. Louis. The new territory, known as the Central States District, will consist of Missouri, Kansas, and southwestern Illinois. Offices are located at 7614 Wydown Blvd., St. Louis 17, Mo.

• Flights Doubled . . . Passenger flights from New York to Europe were increased nearly 100 per cent by **Trans World Airline** as of June 1. Weekly flight frequencies during April of 34 east and westbound crossings jumped to 48 on May 1 and to 66

Erratum

In my "Impressions"—Part II, (AERONAUTICAL ENGINEERING REVIEW, Vol. 9, No. 4, pp. 18–27, April, 1950), page 21, first column, last paragraph, I stated: "Open to question in this paper, however, is the assumption that a rigid engine mount is always used, transmitting all the gyroscopic and vibratory forces directly to the aircraft structure." This statement is not correct, since the authors did assume a flexible connection. In writing this paragraph, I transcribed some of my shorthand notes from the spoken version of the paper and, unfortunately, did not have a preprint to correct my false impression.

Therefore, I inadvertently jeopardized the prestige of Mr. Scanlan and Mr. Truman, for which I sincerely apologize and blame myself for too much haste in meeting the deadline.

STEPHEN J. ZAND

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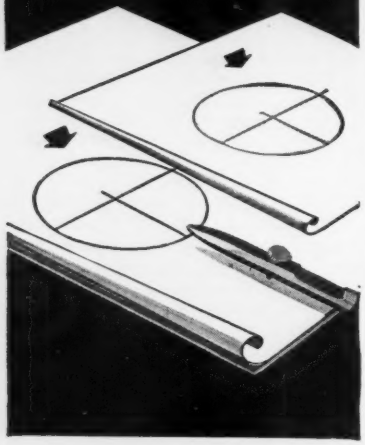

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on June 1. New schedules, together with extra sections, give T.W.A. an average of five daily flight departures from LaGuardia Field to European cities... T.W.A. and Trans Canada Airline have signed an agreement providing for through international air-cargo rates between all points on T.W.A. overseas and all points in the U.S. and Canada on T.C.A. . . . T.W.A. exceeded all records for gross revenue and volumes of passengers, mail, and cargo carried in 1949 while concurrently cutting operational costs below the actual 1948 level to earn a net profit of $3,709,000. Earnings of $1.57 per share of common stock outstanding were the first for T.W.A. since 1945 and contrasted with an adjusted net loss for the previous year of $1,278,000. The 1948 losses were originally reported as $479,000, but under the Civil Aeronautics Board order of August 10, 1949, they have been adjusted to include additional amortization of international development and other costs. Gross revenues of $105,985,000 compared with $101,050,000 in 1948, an increase of nearly 5 per cent, and were accounted for principally by substantial increases in number of revenue ton-miles flown in passenger and cargo service. Passenger revenues jumped $5,867,000, while cargo receipts increased $493,000. Savings within the company, effected in part by consolidation of the international overhaul base at Newcastle, Del., with the main base at Kansas City, reduced total operating expense by $859,000. Total long-term debt was reduced by $6,751,000, and net working capital advanced from $9,208,000 to $16,081,000. These gains were accomplished in the face of the sterling devaluation of September, 1949, which affected the international passenger-fare and cargo-rate structure.

● U.A.C. Reports . . . **United Aircraft Corporation's** net income for 1949 was $10,093,182 on sales totaling $227,085,032. The 1949 net income compares to a net of $9,423,718 on sales of $207,956,522 in 1948. Total current assets on December 31 amounted to $104,231,986 compared with total current liabilities of $24,621,993. Contracts, orders, Government letters of intent amounted to approximately $310,000,000 at the beginning of 1950, compared to orders of approximately $335,000,000 at the beginning of 1949.

● Record Traffic . . . The highest traffic volumes in the history of **United Air Lines, Inc.,** were achieved during 1949. As compared with 1948, revenue passenger-miles were up 10 per cent; mail ton-miles, 14.5 per cent; and freight ton-miles, 20 per cent. Only express ton-miles declined, showing a loss of 9 per cent from the previous year. Both the passenger-mile and freight ton-mile figures represented new all-time company records, while that for mail was exceeded only in the abnormal war years. The increase of 10.5 per cent in total ton-miles carried was accomplished at the same time United reduced its airplane miles flown by 7.5 per cent. Regularly scheduled flights accounted for 53,452,000 airplane miles in the year, with approximately 271,000 miles of special flights and 1,338,000 miles of extra passenger and cargo sections. Operating costs per ton-mile were lowered 8 per cent as

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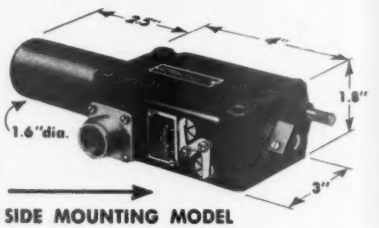

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compared with 1948. Whereas revenue ton-miles flown were up 10.5 per cent over 1948, total operating expenses increased only 2 per cent. The use of the U.A.L. Maintenance Base at San Francisco has resulted in savings in excess of $750,000 annually. Financial gains in 1949 permitted the reduction of debt, an uninterrupted record of preferred dividend payments, and the maintenance of a strong cash position.

• Best Year . . . Net income of **Westinghouse Electric Corporation** in 1949 was the highest in the company's history—totaling $67,268,555—in spite of a decline in net sales. Record income is attributed to new and more efficient manufacturing facilities, operating economies, and excellent teamwork of Westinghouse employees.

I.A.S. Sections

Chicago Section

Alfred F. Stott, *Secretary*

The meeting of March 28 got off to a fine start with 38 members and guests assembled for dinner in the Student Union Building of Illinois Institute of Technology. Sixty-five members and guests gathered to hear Raymond D. Kelly, United Air Lines, present a paper on "Turbine-Powered Transport Development." Mr. Kelly opened the discussion by telling of his flight to Europe for the purpose of visiting aircraft and engine factories and air lines and to observe the progress of jet transports abroad. He made several flights in the latest type of British turbine-powered planes.

▸ **Turbojet vs. Turboprop**—He indicated that the turbine jet plane, which cruises at 500 m.p.h. or more, still appears to be the commercial airplane of the distant future but that the turboprop airplane appears near at hand for air-line use. The turboprop seems the logical next step, since its operating characteristics are not much different from those of our present type of airplane. This type of aircraft can get into and out of small airports and may better fit the present-day traffic patterns than a pure jet aircraft. The turboprop offers smooth acceleration, low noise level in the cabin, and nearly vibrationless passenger comfort. Pure jets offer top speed, but this is only of value for long flights at high altitudes.

Present traffic conditions do not warrant enough long-distance flights to make pure jets feasible. Reliable block-to-block speeds, low fuel consumption, ability to fly around or over the weather and ranges which will not penalize pay load are all to be considered in selecting transport equipment. Some curves were shown which compared jet, turboprops, and reciprocating-engine-powered aircraft with reference to pay load, fuel consumption, speeds, etc., at various altitudes. Some interesting high-altitude wind conditions were discussed. An extremely interesting question-and-answer session followed the regular meeting.

Los Angeles Section

Harrison A. Storms, *Secretary*

The regular dinner meeting of the Section was called to order on March 16 in the I.A.S. Auditorium. Dr. A. E. Puckett, honorary chairman, introduced the speakers for the evening.

▸ **Digital Computers**—J. H. Weaver, Telecomputing Corporation, spoke on "Application of Digital Computers in Aeronautical Problems." In beginning his paper, Mr. Weaver gave a brief history of the development of computers up to the various improved IBM machines. He then discussed the handling of problems on the latest IBM machines (#604).

This equipment has been used to solve problems of the following types: wing and fuselage structural analysis; all problems of the simultaneous equation form; reduction of wind-tunnel data; spanwise lift distributions;

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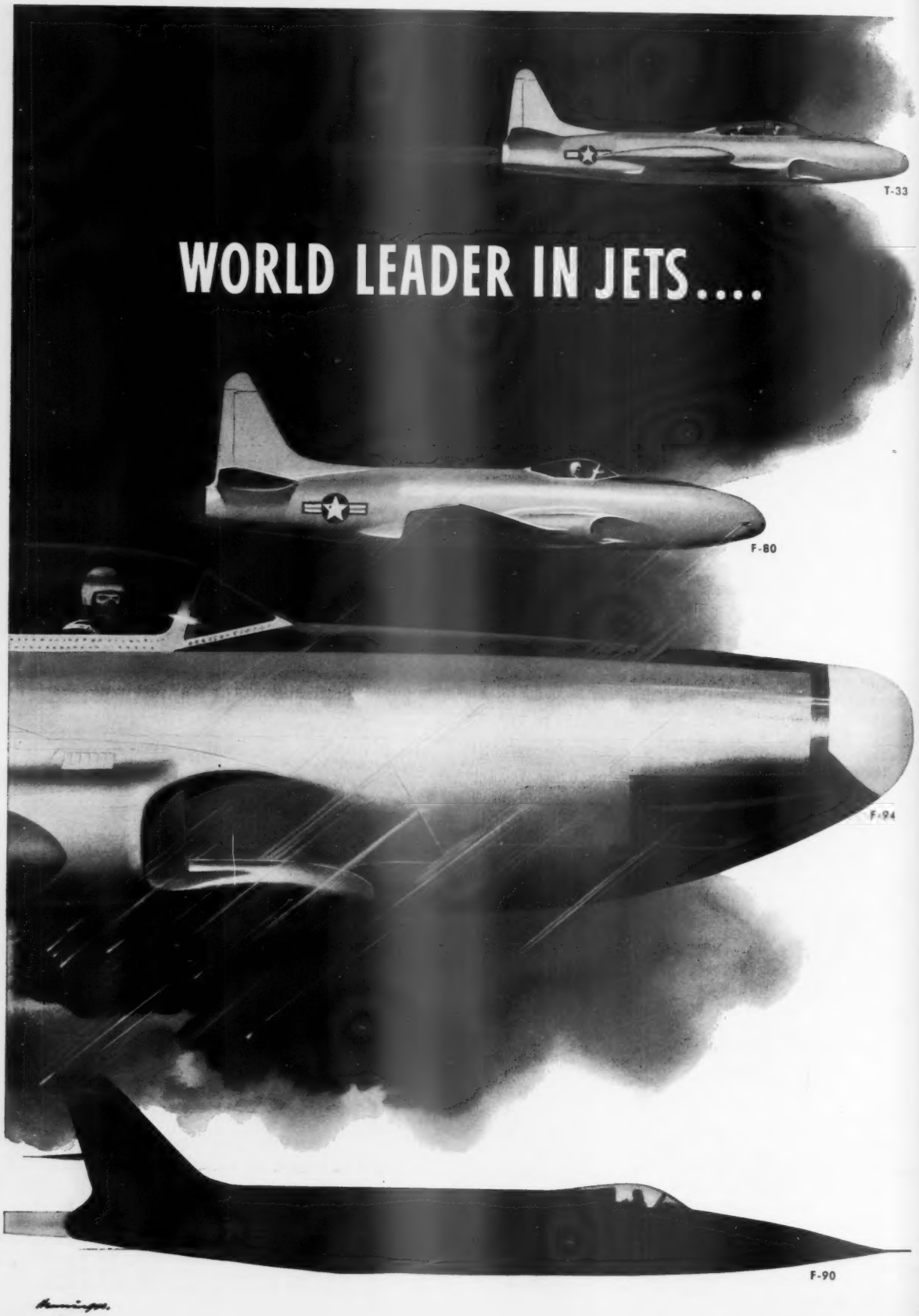
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Lockheed produced the first U. S. operational jet airplane—the famous F-80 *Shooting Star*, long the backbone of America's fighter defense.

Lockheed leads in the jet training program, too, producing the two-place T-33 and the TO-1 jet trainer for the Air Force and the Navy. These are the only jet trainer airplanes produced in America today.

And to win and maintain air superiority *behind* enemy lines, Lockheed has built the long-range, twin-jet F-90 Jet Penetration Fighter.

Now, for high-altitude interception, Lockheed is building the new F-94 All-Weather Interceptors, capable of around-the-clock, around-the-calendar defense.

These dependable Lockheed Jets have many mutual advantages—speed, strength and producibility. And the experience obtained in the design, development and manufacture of these practical jet airplanes is invaluable in the Lockheed laboratories where the planes of the future are taking shape today.

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static aileron reversal speeds; runway take-off calculations; reduction of missile flight data; jet-engine performance (ram effects, altitude effects, etc.); problems in harmonics; and some types of performance problems.

The following types of problems are not suited for digital computers, unless accuracy is primary: dynamic stability and flutter problems, transient load problems, and servomechanics analysis. In conclusion, Mr. Weaver stated that analog and digital computers complement each other very well. Both, operating individually and together, will handle all types of automatic computations necessary in the aircraft industry for some time to come.

▸ **Analog Computers**—The second paper, "Applications of Analog Computers in Aeronautical Problems," was presented by Dr. G. D. McCann, Professor of Electrical Engineering, California Institute of Technology. Dr. McCann opened his paper by stating, in agreement with Mr. Weaver, that there was no one type of computer capable of handling all problems of mathematics or science. The most important and most difficult part of a problem solution, for example, with the digital computer, is in the proper setup of the problem and in checking the machine computations. All types of problems that are of the differential equation type or are analogous to electric circuit theory may be solved on the analog computer. The average accuracy of problem solutions is approximately ±1 cer cent, however, accuracies in some case may be as good as ±0.01 per cent. Several slide photographs and diagrams of the analog computer as used at CalTech were shown, with explanations illustrating the circuits used for various problems.

Some of the problems solved on this computer are: motions and stresses in an aircraft landing gear during drop tests (load-stroke curves); analysis of misfire in an aircraft radial engine, taking into account mechanical backlash, torque, etc.; current force analogy for uncoupled bending as applied to straight or curved plates and brams; complete wing and fuselage structural analyses for various loading conditions, as well as for individual cellular divisions of any portion of the wing or fuselage; flutter and vibration problems in aircraft structure and for control surfaces; stresses in aircraft structure due to applied gusts; and reduction of all types of wind-tunnel data.

In general, most types of problems that can be solved on the digital computer can be solved on the analog computer, although here again it was men-

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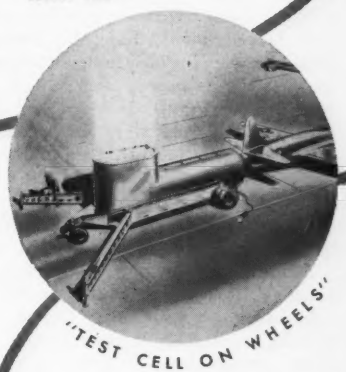

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tioned that some types of problems are not so well suited to the one as to the other type of computer. The solutions to the majority of the problems on the analog computer appear as time-history plots of the particular function being investigated.

After a brief period of questions and general discussion, the meeting was adjourned. Approximately 150 members and guests attended.

Washington Section

Bernard Maggin, *Secretary*

Rear Admiral L. B. Richardson, U.S.N. (ret.), Director of Research and Development, Fairchild Engine and Airplane Corporation, and Adm. DeWitt C. Ramsey, U.S.N. (ret.), President, Aircraft Industries Association of America, were the principal speakers at the meeting held on April 11, which was attended by 120 persons. The dinner preceding the meeting was attended by 60 I.A.S. members and guests.

Admiral Richardson, who is an I.A.S. Fellow and a Member of the I.A.S. Council, spoke on "Industry's Role in Translating Research into Aircraft Development." After examining the development of the present close relationship between the aviation industry and the Government, he summed up the means by which the industry can meet its peacetime assignments.

▸ **The Research-Engineering Team**—Admiral Richardson emphasized that "we do not today give quite enough consideration to the speed with which research is giving the aircraft industry new knowledge with which to work and to the greater coordination that must be achieved between the research scientist and aeronautical engineer.

"This situation requires close attention, for both engineering and scientific groups comprise strong personalities that cannot be formed into teams overnight, no matter how great an emergency may dictate that they work in harness together. . . At the same time, these technical teams cannot exist in a vacuum but must be, in their turn, parts of a larger team comprising management, production engineers, and facilities, for the final translation of research into an aircraft of any kind requires all of the elements mentioned, all working in the closest harmony."

▸ **Reporting of Research Data**—"One of the most important fields for improvement is in the matter of obtaining basic research information from universities and Government laboratories in time for such data to be of value for aircraft development purposes. Industry often is forced to resort to makeshift research experimentation in the course of aircraft development in order to attain the immediate objective of providing a satisfactory military weapon or vehicle. Streamlining and expediting of procedures for reporting and publishing research data obtained through the N.A.C.A. and other agencies would be a real assistance to the industry in the development and production of new aircraft. This has always been true, and the current rapid rate of progress adds emphasis to it now.

"Industry could also use *more* information on the various types of research being conducted at any given time by the Government, and by other agencies on Government contract, in order to carry out its responsibilities efficiently in the field of development, just as the services could always use *more* aircraft, personnel, materials, and money. We must be sure that industry is provided all the material it can efficiently use, in the form of knowledge as well as of tangible things. 'From Knowledge—Sea Power'—the time-honored motto of the Naval Academy—can emphatically be applied, with the change of only one word, to the situation facing every individual and organization in our aeronautical activities today."

▸ **Turbojet Transport Aircraft**—Admiral Ramsey stated that the absorption of turbojet aircraft into the country's airway and airport traffic patterns would have to wait until the all-weather flight-control program of the Radio Technical Commission for Aeronautics had been completed in its interim phase. He expected that this would take place in about 4 or 5 years. Admiral Ramsey also urged Government support to finance the development of prototype turboprop and turbojet commercial air liners.

Student Branches

Case Institute of Technology

At the March 22 meeting, the following new officers were elected: Chairman, Robert W. Carr; Vice-Chairman, Roger M. Duncan; Secretary, Leonard Gelfand; and Treasurer, Robert A. Chirakos.

Forty persons heard William A. Fleming, of the Lewis Flight Propulsion Laboratory, N.A.C.A., speak on "Research Techniques in the Study of Turbojet Engines."

Mr. Fleming gave an illustrated lecture on the effect of altitude on the operation of turbojet engines as compiled in tests performed at the laboratory. He also explained the construction and operation of the altitude testing equipment. Also illustrated were the techniques used in obtaining internal performance data at critical points in turbojet engines. After the talk there was a question-and-answer period.

Catholic University of America

Guest speaker at the meeting on March 15 was Bernard Tambourini, Navy Bureau of Aeronautics, whose topic was "Carrier Adaptability of Aircraft." Thirty persons were present.

Mr. Tambourini spoke of the important differences between designing aircraft for carrier operations and for fixed-base operations. The use of such devices as catapults, Jato, and arresting gear make for serious problems in stress and weight designing. All carrier-based aircraft must be heavier than comparable land-based aircraft in order to stand up under the shock of the sudden accelerations and decelerations necessary in carrier operations. The size of the deck elevators of the carriers is a major design factor in carrier-based aircraft. If the plane cannot be brought down the elevator, it is of little value. The height of the hangar deck and space limitations add to the complexity of the design of Naval carrier-based aircraft. It is necessary to incorporate such devices as folding wings and vertical tail surfaces to get as many aircraft as possible aboard the ship. These devices add more weight to the aircraft, and further problems ensue. Following the discussion period, Woodrow Seamone, Chairman, presented an engraved cigarette lighter to Mr. Tambourini in appreciation of his lecture.

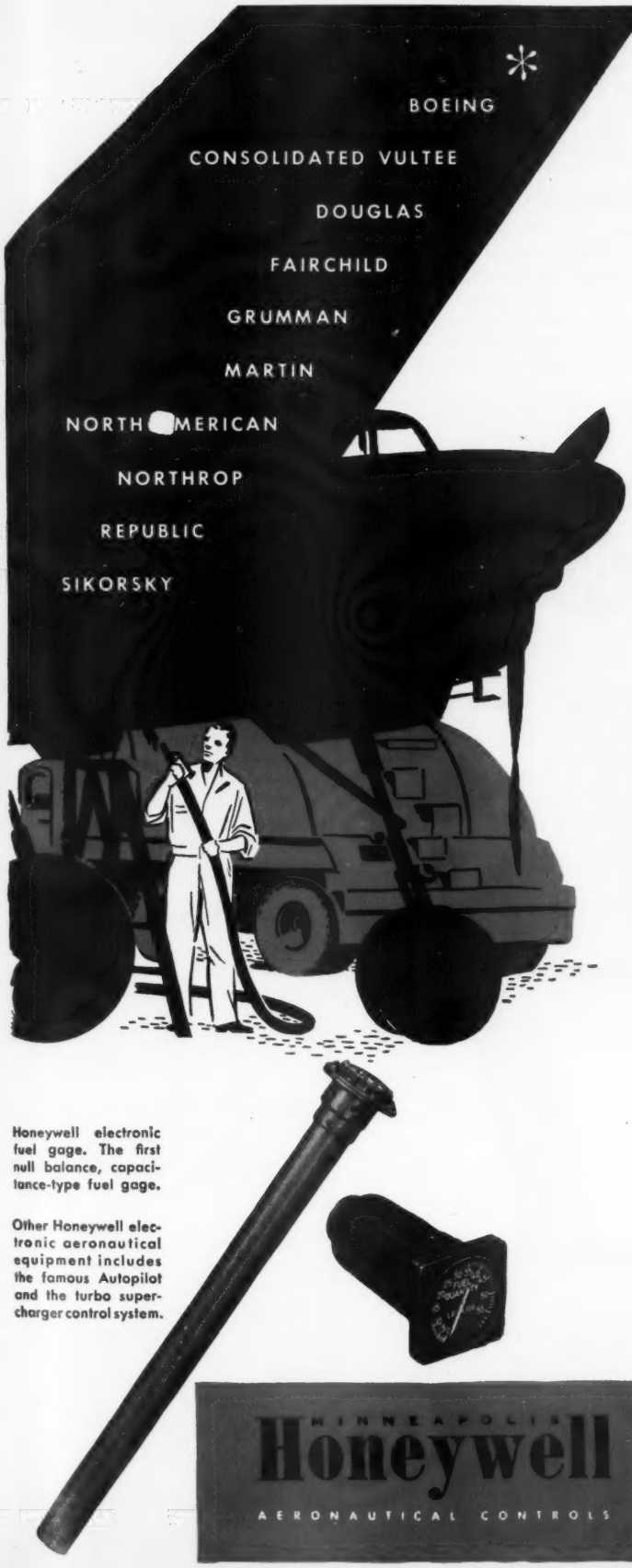
Louisiana State University

On February 23, three U.S. Air Force films on air combat and bombing were shown to the 21 members present.

During the March 9 meeting, 75 members and guests were entertained with a showing of U.S.A.F. motion pictures on the invasion and bombing of Germany during World War II.

Massachusetts Institute of Technology

Dr. Jerome C. Hunsaker, Head, Department of Aeronautical Engineering, spoke on the history and current activities of the I.A.S. at the February 9 meeting. New officers



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were also elected: Chairman, H. R. Jex; Vice-Chairman, M. A. Hoffman; and Secretary-Treasurer, L. J. Tedeschi.

Northrop Aeronautical Institute

The bimonthly dinner meeting was held in the I.A.S. Western Headquarters Building on February 10. Newly elected officers were introduced as follows: Chairman, F. C. Smith; Vice-Chairman, B. K. Bennett; Secretary, W. J. Poppe; and Treasurer, B. R. Walker. Speaker of the evening was Gibs Raetz, Aerodynamicist, Northrop Aircraft, Inc., who presented an illustrated lecture on his method of calculating aircraft performance. The method may be applied to aircraft using any type of power plant and operating in either the subsonic, transonic, or supersonic ranges at any of the extreme altitudes.

University of Oklahoma

The meeting of February 8 was sponsored jointly by the I.A.S. Student Branch and the student branches of the S.A.E. and the A.S.M.E. Robert Boyer, General Electric Representative and Coordinator at Tinker Field, Oklahoma City, presented a paper on the "Cycle Analysis of the Jet Turbine."

The Pennsylvania State College

The first meeting of the semester was held on February 22. A U.S. Navy film, *Able and Baker Bikini Test*, was shown to the members.

Results of the elections held at the March 29 meeting are as follows: Chairman, William Hendershott; Vice-Chairman, Richard Gavalis; and Secretary-Treasurer, William Schlegel. Two motion pictures were shown at this session. The first film, *Hamilton Standard Propellers*, pointed out the advantages of constant-speed propellers and feathering and showed the mechanisms employed to perform the respective operations. The second film, *Nazis Strike*, depicted the outset of World War II and the importance of aircraft in a "softening-up process."

Purdue University

The February 21 meeting began with the introduction of the new Branch officers: Chairman, Richard D. Freeman; Vice-Chairman, Joseph C. Wright; Secretary, Jacqueline Canfield; and Treasurer, Jerry F. Falto. Dr. Eugene F. Lundquist, Chief, Structures Research Division, Langley Aeronautical Laboratory, N.A.C.A., spoke on "Structures for Supersonic Aircraft and Research as a Career." His talk was supplemented by slides made by the N.A.C.A.

Rensselaer Polytechnic Institute

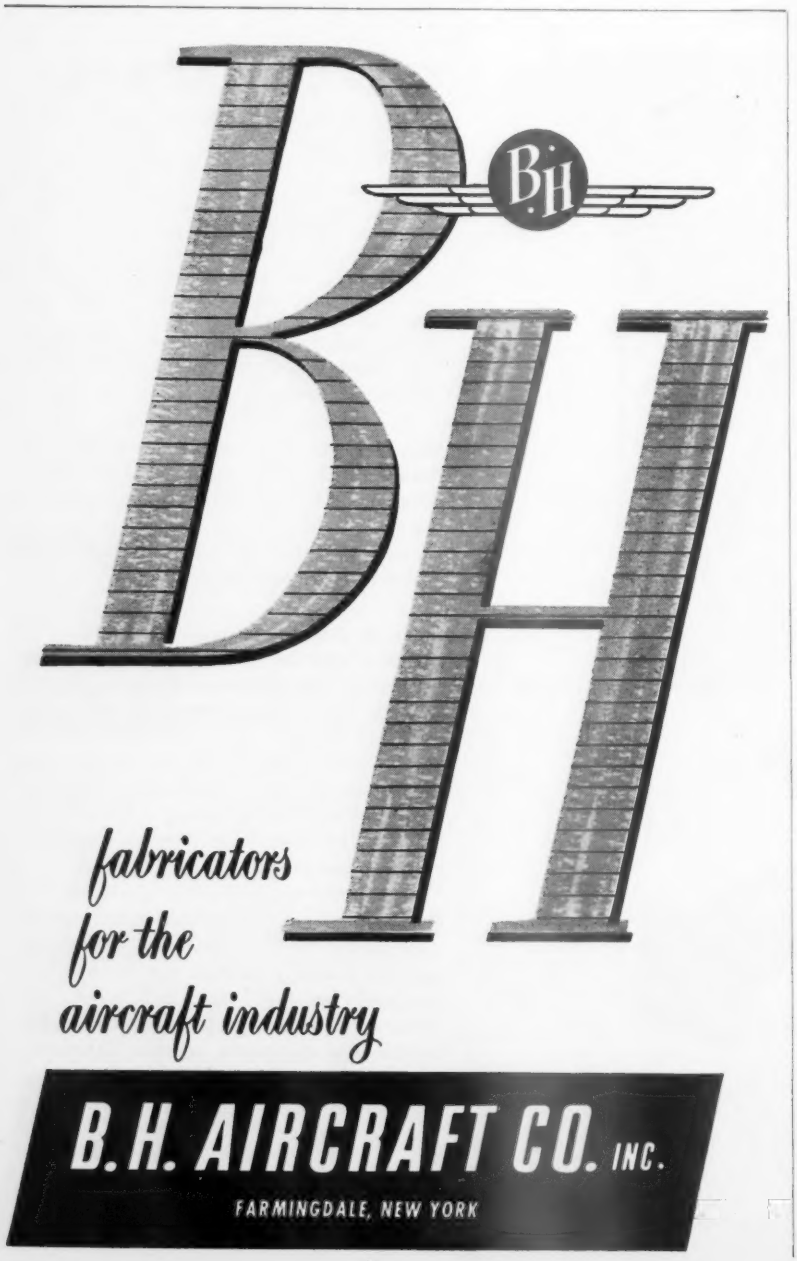
Robert Rosenbaum, Chief, Aerodynamics Section, Airframe and Engineering Division, N.A.C.A., spoke at the February 22 meeting. His topic was "Aeroelastic Effects Associated with Fast Transport Flight." A motion picture, *Flutter Model of the Boeing B-47*, followed Mr. Rosenbaum's talk.

Spartan College of Aeronautical Engineering

The Aluminum Company of America provided the motion picture, entitled *Curiosity Shop*, which was shown at the February 7 meeting. The film described the problems that arise during research and development for improved aluminum products.

A. & M. College of Texas

Fred E. Weick, Director, Personal Aircraft Research Center, A. & M. College of Texas, was guest speaker on February 21. He spoke on the new agricultural airplane being developed at Texas A. & M. and ex-



plained the general purpose and present trend of the agricultural airplane. Earlier in the evening, new officers were elected as follows: Chairman, John Taylor; Vice-Chairman, Clyde Fittz; and Treasurer, Roger Tate.

University of Tulsa

"Flight Meteorology" was the principal topic discussed at the February 16 meeting. The speaker was Everett Garrison, a former P.A.A. meteorologist and now a student of aeronautical engineering at Tulsa. Two films were shown—*Air Masses and Fronts*, prepared by the C.A.A., and *The Phantom*, prepared by McDonnell Aircraft Corporation.

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. Members. A brief letter or postal card giving *exact* details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th Street, New York 21, N.Y.

News of Members

Richard S. Boutelle, M.I.A.S., President, Fairchild Engine and Airplane Corporation, has been named to the Advisory Council for Civil Defense of the State of Maryland. Advisory Councils will act on the state level to aid in implementing national planning and to suggest action to meet the particular needs of the various states.

Robert F. Brodsky, T.M.I.A.S., has been elected to the New York University Chapter of Sigma Xi. Mr. Brodsky is an Instructor in the Department of Mechanical Engineering, N.Y.U.

Keith G. Brown, A.M.I.A.S., is now Engineering Librarian, Fort Worth Division, Consolidated Vultee Aircraft Corporation. Keith Brown was formerly Project Librarian, Standard Aeronautical Indexing System, at I.A.S. Headquarters in New York.

J. A. Herlihy, M.I.A.S., Vice President—Operations for United Air Lines, Inc., has received a diamond-studded gold pin to commemorate his 20 years' service with the company.

William T. Raymond, A.M.I.A.S., has been appointed Assistant to Eastern Air Lines' Vice-President M. M. Frost. Formerly Director of the Governmental and Public Affairs Department of the Air Transport Association and Assistant to the Executive Vice-President of that organization, Mr. Raymond will be actively engaged with matters pertaining to E.A.L.'s route development and the air line's civil and public affairs program.

Robert A. Wells, M.I.A.S., is now Chief Fuels and Lubricants Engineer, Aviation Section, Product Development and Product Engineering, for Gulf Oil Corporation. Mr. Wells will furnish the Domestic Marketing Department with data, manuals, technical bulletins, and technical service on the application and performance of company products in aviation equipment.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Chieri, Pericle A., Doctorate in Ae.E., Assoc. Prof. in Mech. Engineering and Member of Graduate Faculty, Newark College of Engineering.

Transferred to Associate Fellow Grade

Dysart, Joseph J., B.A., B.S.Ae.E., Maintenance Manager (Miami Overhaul Base), Pan American Airways, Inc.

Michel, Philip L., M.A.E., Assoc. Prof. of Aero. Engineering, North Carolina State College.

Elected to MEMBER Grade

Barnes, Jess W., S.M. in Ae.E., Comdr., U.S.N.; Planning Officer, Aviation Armament Lab., Naval Air Development Center (Johnsville).

Bentley, Frank K., Asst. Prof. of Aero. Engineering, Massachusetts Institute of Technology.

Benun, David, B.S. in Ae.E., Unit Head, Flutter Engineer, Curtiss-Wright Corp.

Bland, Reginald B., Aero. Research Consultant, self-employed.

Brising, Lars H., M.S. in Ae.E., Chief Engineer and Head, Airplane Design and Development Depts., SAAB Aircraft Co.

Carrick, Harold J., Prof. of Aero. Telecommunications and Air Traffic Control, Instituto Technologico de Aeronautica (Brazil).

Homer J. Wood.

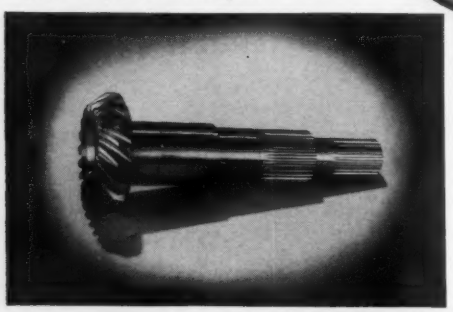
WRIGHT BROTHERS MEDALISTS

Homer J. Wood, M.I.A.S., Assistant Chief Engineer of Turbine Development, and Frederick Dallenbach, M.I.A.S., Turbine Design Engineer, both of AiResearch Manufacturing Company, received the 1949 Wright Brothers Medal on April 17. The Wright Brothers Medal is awarded annually by the S.A.E. for the best technical paper on aircraft design and development or aerodynamics presented at an S.A.E. meeting. This year's award honored Messrs. Wood and Dallenbach for their jointly written paper, "Auxiliary Gas Turbines for Pneumatic Power in Aircraft Applications."

Frederick Dallenbach.

the P.A. from So. Carolina said to the P.A. from No. Carolina

Transmission bevel gear for Sikorsky S55-Helicopter



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The Technical and Scientific Aeronautical Monthly

Edited by

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Single Copies: 35 cents post free

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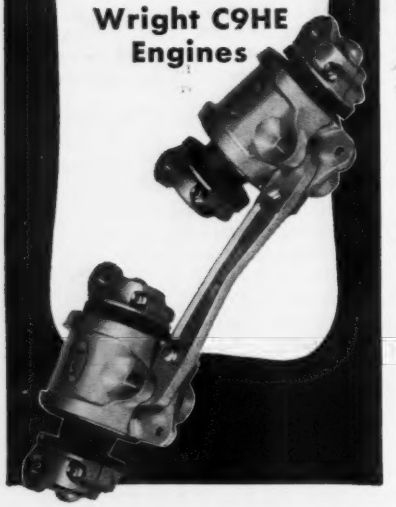

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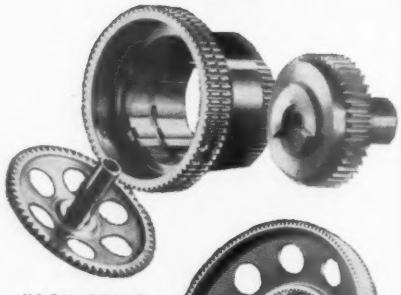

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184. Stress Analyst—B.S. in A.E., 1947. Two years with leading manufacturer. One year of electrical and 6 months of architectural drafting experience. Three years in the U.S.A.A.F. Location open. Age 27.

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182. Aero-Mechanical Engineer—B.Aero.E., 1943; M.M.E., 1949. Extensive experience, including supervisory duties, in the field of jet power plants. One and one-half years' design experience on all major power-plant components with leading aircraft manufacturer. Two and one-half years' experience in research and development with the N.A.C.A. as P-3 Aeronautical Research Engineer on ram-jet power plants (subsonic and supersonic) and rocket launchers. Position entailed design of test equipment, setting up test program, testing, processing of data, analysis of data, and technical report writing. Development work included various configurations of diffusers, nozzles, and combustion chambers. One year as Junior Project Engineer with well-known turbojet engine manufacturer doing preliminary design and performance estimations. For past 2½ years, member of Faculty, Mechanical Engineering Department, Grade A Engineering School, lecturing in thermodynamics. Worked with Research Division of University during summer months on the development of advanced type power plants. Procedures for analysis required the use of schlieren photography for flow studies. Had occasion to use special instrumentation for measurement of pressure and temperature which had been adapted to rocket performance studies. Will

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181. Engineer-Administrator—Twenty-three years' experience in aircraft and engine manufacturing as engineer, technical representative, and administrator. Familiar with Government policies and personnel of Government agencies and the industry. Formerly director of market research, administrator of research and development contract, BuAer project officer, executive office manager, contract administrator, technical assistant to treasurer, and consultant.

178. Layout Draftsman—Aeronautical sheet-metal-production design. Age 35. Five years of aeronautical drafting; 1½ years of rail car design. Two years of night school, University of Maryland, drafting. Desires position as aeronautical draftsman or in sheet-metal-production design. Location open.

177. Research or Teaching—Doctor of Aeronautical Engineering. Varied experience over a period of 8 years in the fields of design and research in fixed- and rotary-wing aircraft. Teaching position preferred either on the East or the West Coast.

176. Mechanical Engineer—B. of M.E., 1950; 3 years' experience with leading aircraft instrument manufacturer as repairman of all instruments; as instructor of Allied and American military personnel and heads of instrument departments of major aircraft companies; also some research engineering. Three years' additional experience in the U.S. Army Signal Corps as a teletype, telephone, and switchboard installer-repairman; French and German interpreter; and director of European civilian labor. Part-time experience in the planning, organizing, and procurement for new courses of instruction in a technical school. Desires a position in the instrument or electronic field. Location open. Age 29.

175. Engineer—Instructor—B.Aero.E., M. Aero.E., Professional Engineer. Two years of aerodynamics in stability and control, performance, air loads, and wind tunnel. One and one-half years as research engineer with precision instrument firm on East Coast. Experience includes precision experimental instrument design and test, purchasing, and shop liaison. Now finishing second annual contract as Instructor in Aeronautical Engineering in a New England college. Would prefer Assistant Professorship in New York or New England area or responsible industrial position. Will relocate if attractive. Full knowledge of present employer.

174. Associate Professor—S.M., M.I.T. Head of aeronautical engineering option at northern college desires position of corresponding responsibility in either teaching or research. Opportunity to pursue doctorate on part-time basis desirable. Location open.

173. Engineer—Six years' experience in aircraft and aircraft control system dynamics. Specialist in devising and analyzing servo controls for pilotless aircraft. Has directed analog computer studies of autopilot designs.

172. Aircraft Stress Analyst—Mechanical Engineer—Four years' experience as aircraft stress analyst. Graduate of Spartan College, Tulsa, Okla., and The University of Oklahoma, Norman, Okla., with degrees of A.A., A.E., and B.S., M.E. (Aero. option). Ability to maintain authoritative and friendly relationships with draftsmen, design groups, liaison, shop, etc. Prefers to do stress and/or structural design work in Missouri, Kansas, or Illinois area.

171. Engineer—Eleven years' engineering and 5 years' sales experience as factory representative; management and some production experience; graduate University of Michigan and Alexander Hamilton Institute of Business Administration. Wishes to apply experience in the production department or to assist in coordinating production, sales, and engineering departments. Locality and salary open. A detailed outline of experience will be sent on request.

170. Aeronautical Engineer—Nine years' experience in airplane manufacture. Three years'

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169. **Sales Executive and Economist**—Familiar with operating and market analysis; extensive management and sales experience in this country and abroad; widespread Government and industry contacts; 10 years in Washington. Technical background, two degrees, pilot, and well-known writer. Prefers East Coast location, but will go anywhere.

168. **Teacher**—Desires position teaching aeronautical engineering or engineering mechanics at recognized college or university. B.Ae.E. degree, Magna Cum Laude. M.S. in Ae.E. Three years of progressively responsible industrial experience, including stress analysis and design of tubular and stressed-skin structures and of the mechanical elements of civilian and military aircraft with emphasis in rotary-wing field. Over 4 years of college teaching experience as instructor and assistant professor. Qualified to teach graduate courses in theory of elasticity and elastic stability, experimental stress analysis, rotary-wing aerodynamics, etc., as well as undergraduate curriculum in aerodynamics, aircraft structures, and airplane design. In reply, please discuss rank available and salary schedule.

166. **Aeronautical Engineer**—Research Aerodynamicist with 7 years' practice. Doctor's degree. Age 28. Author of several papers. Has worked on propulsion and supersonic problems. Presently working on original analytical design procedures for compressors and turbines. Experienced report writer. Desires supervisory research position or consulting work. Also interested in the hydrodynamic propulsion problems of watercraft.

164. **Air-Line Operations Engineering—Airport Management**—Training at Denver University, Parks College, and Spartan School of Aeronautics in Operations and meteorology and technical writing. Four years with A.A.F. Intelligence dealing with restricted and confidential manuals in maintenance and Air Transport Command Flight Operations. Familiar with air-line operations problems at large eastern airports. Also trained in A.A.F. 1st Helicopter Training Unit. Has postwar training in latest sales and airport and aircraft insurance underwriting procedures. Prewar aeronautical engineering training at V.P.I. Extension and at University of Alabama. Desires position with large fixed-base or airport management assistant.

165. **Aeronautical Engineer**—Summer position. M.Ae.E., New York University in June, 1950. Beginning doctoral work in September. One year's industrial experience in design and stress analysis. Age 26. Prefers stress analysis or teaching but will consider any offer in New York vicinity.

163. **Aeronautical-Mechanical Engineer**—B.S. in Ae.E., January, 1950; "A" average. One year time and motion study in night school. One year's experience in product design (industrial magnets). Three years in Naval Air Service as aviation mechanic and air cadet. Holds private pilot's license. Age 23. Location open. Available for interview.

162. **Aeronautical Engineer**—Graduate of the Academy of Aeronautics. Two years' experience in aircraft design. Familiar with fabrication procedures. Age 27. Primarily interested in design.

161. **University Teaching—Wind-Tunnel Operation**—Wind-tunnel assistantship, and M.S. in Aeronautics, Cal. Tech. Ten years' experience in all phases aerodynamics with several aircraft manufacturers. Specializing in wind-tunnel testing, including model design, testing, and tunnel operation, analysis of results, and company representation. Position teaching and wind-tunnel operation desired.

158. **Aeronautical Engineer**—Recent graduate in Aeronautical Engineering, equivalent of four years' intensive study. Familiar with aircraft materials, limitations, tolerances, processing, and production. Seven months' experience with actual data reduction for guided-missile telemetering. One year's experience as airplane and engine mechanic on two- and four-engined aircraft. Desires junior position that requires mechanical inclinations with engineering thinking. Location open. Age 23.

157. **Aeronautical Engineer**—Age 24. Graduate of Academy of Aeronautics in Aircraft Design and Construction, August, 1949. Two years' civilian and 1½ years' military experience in aircraft, instrument, and engine overhaul and maintenance on transport aircraft. Background includes "A" license. Six months with aircraft engine manufacturer as tester of experimental jet engines and accessories. Desires position as junior engineer in or about New York City area.

156. **Aeronautical Engineer**—Age 24. Graduate of Stewart Aviation School, design course, Two years' mechanical design experience. Won I.A.S. student lecture award and also student aircraft design award. Flight engineer on B-17 (8th Air Force) during war, 2,500 hours' flight time. Graduate of various Air Force schools. Prefers aircraft design or flight testing. Location open.

155. **Research Engineer**—Bachelor of Aeronautical Engineering. Four years' experience in overall aerodynamic and analytical studies pertaining to design of all types supersonic guided missiles and aircraft. Desires responsible position with aircraft company, research facility, or university located in East or Middle West. Position need not be in field of supersonic research; opportunities for independent and interesting work most desirable.

154. **Jet Propulsion and Aeronautical Engineer**—B.S., M.S. Aero. E. Twelve years' experience in aircraft and liquid rocket design. Last 4 years as liquid rocket and jet propulsion design group leader. Previous 8 years as aircraft structural design engineer, group leader, and project engineer. Qualified engineer, organizer, supervisor, and administrator. Age 34. Desires responsible position in liquid rocket or jet propulsion field or aircraft design (utilizing jet power).

153. **Engineer**—Young man desires research or teaching position with educational institution. Doctor's degree in Aeronautical Engineering, considerable research experience. Has been in responsible charge of theoretical and experimental research projects in the fields of structures, elasticity, and aerodynamics. Some teaching and industrial experience. Several publications. Location open.

152. **Aeronautical Engineer**—B.S. Degree in Aeronautical Engineering. Two years' experience in transonic wind-tunnel work comprising wind-tunnel operation, balance calibrations, data reduction, and development work. Previously, four years' experience in the Army Air Force as Engineering Officer in charge of heavy bombardment aircraft maintenance. Also experience in lofting and perspective drawings. Desires position in aerodynamics, development work, or other related engineering work. Other engineering fields will be considered. Age 28.

151. **Manufacturers Military Sales Representative**—Aeronautical Engineer, B.Ae.E. Fourteen years' experience both in the aviation industry and the Air Materiel Command at Wright-Patterson Air Force Base. Positions in industry included project engineer, staff engineer and factory representative to the Air Materiel Command, covering both technical and administrative duties. Duties with A.M.C. included design, stress analysis, airplane project engineer, which afforded close and frequent contact with both A.M.C. and aviation industry engineers. Can be of value to aeronautical equipment manufacturer seeking Air Force contracts or currently a contractor to the Air Forces.

150. **Aeronautical Engineer**—B.S. in Mechanical Engineering (Aeronautical Option) from Purdue University. Eight years of experience in aerodynamics, ground and flight testing, powerplant installation design, preliminary aircraft design, project engineering, and project administration. Has worked on piloted and pilotless aircraft of most classes and on reciprocating, turboprop, turbojet, and pulse-jet power plants. Exceptional talent for, and experience in, the preparation of engineering reports and proposals. Familiar with technical aspects of Navy and Air Force contracts. Long experience in the preparation of correspondence to the armed services. Able to plan, organize, and schedule any type of engineering project. Registered professional Engineer, State of California. Prefers location in Los Angeles area. Immediately available.

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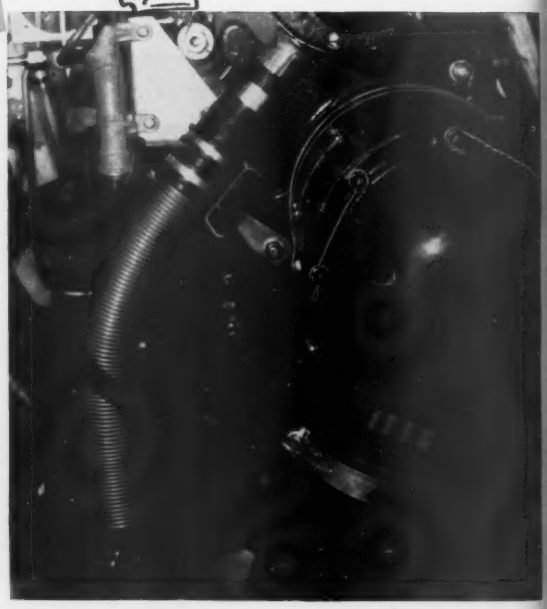

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